ROADS and STREETS

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Why Should Not Pavements Be Given an Earth-Macadam Substructure?

It would lead to greater economy if every pavement were regarded as consisting of not less than two layers of entirely different material, namely, a layer of treated earth and one or more layers of other materials.

By treated earth we do not mean merely the customary rolled subgrade, but a subgrade at least six inches of which have been so treated as to constitute a fairly good dry weather pavement itself, a sort of earth-macadam. The treatment of this earthy sub-pavement, as it may be called, would depend upon its nature. If clay, it should ordinarily have sand, gravel or other coarse material mixed with it, before rolling. If sand, it should ordinarily have loam or other fine grained binder mixed with it. If gravel, it should be made into a sort of gravel-macadam. In every case the aim should be to produce a layer of earthy materials, uniformly mixed and thoroughly compacted to a depth of 6 in. or more. The present treatment of subgrades ordinarily is not of this sort.

The primary function of any pavement is so to distribute a concentrated wheel load over the soil as to enable the soil to support the load without injurious distortion of the pavement. A large part of this function can be performed by treating the subgrade itself. This has long been recognized by designers, but what we now urge is much more thorough attention to the treating of the subgrade.

We may be wrong in suggesting an earth-macadam subbase. The present practice may be more economic than a more thorough treatment of the subgrade. But of one thing we are certain. There are not on public record any experiments that disprove our contention that subgrades should be given a more thorough treatment. And, on the other hand, the editor has witnessed some remarkable work in compacting earth with a "rolling tamper" at such a small cost per square yard as to convince him that the ordinary treatment of subgrades can be greatly improved.

The "rolling tamper," or "sheep's foot roller," was first described in Engineering and Contracting Nov. 11, 1908. A reprint of the article with an illustration of the "rolling tamper," may be found in the writer's Handbook of Cost Data, pages 315 to 322. The rolling tamper was invented by John Fitzgerald of Bakersfield, Cal. The patent has expired.

Fitzgerald gave the editor this account of the invention: "I had a contract for surface oiling of a road leading into Bakersfield, and had just plowed up a stretch of the road when along came a big flock of sheep. When the last sheep had passed over that plowed stretch, you could scarcely dent it with an eight-up team on a rooter. Well, I says to my pard: 'If those damned sheep had only waited a few hours, I would have paid 'em money to pack that dirt for me, but now look at it—all hummocks.' And then an idea struck me. I couldn't afford to hire a flock of sheep every time I needed 'em, but why not invent a flock of sheep. So I sawed me out a 5-ft. log, put an axle in it, bored holes all over it, drove in big iron spikes with sheep-like hoofs on 'em, and there was my flock of sheep, ready to be pulled back and forth by mules."

The iron sheeps-feet projected about 8 ins. from the roller, and sank to the hilt in the plowed and harrowed earth, starting compacting it at the bottom. Finally, the soil becomes so compact that the sheep's feet walk on top without sinking; then the job is finished, for a rolling tamper is its own inspector. About 400 sq. yd. are thus compacted in 9 hrs. by one rolling tamper drawn by 4 to 6 mules; but

with a tractor pulling several rolling tampers in tamden, the cost should be considerably reduced. The cost, in any case, is so slight that the only question to decide is the one of effectiveness of compacting the subgrade, and the resulting increase in the carrying power of the pavement.

Sand-clay roads, it seems to us, would be much better if thus compacted, and could be built as sub-pavements.

It would pay, we believe, to haul earthy materials many miles, if by mixing them with the subgrade stuff a much more rigid subpavement could be produced. By using a cultivator and a road grader the earthy materials can be broken up and thoroughly mixed at a very low cost. Then the earthy materials can be hammered with the "sheep's feet" into a mass so dense that a pointed oaken peg can scarcely (often not at all) be driven into it. If a veritable earth-macadam can thus be made at low cost, we feel confident that not to make it as a sub-pavement will usually be an economic mistake.

H. P. Gillette

The Migration from the Farm to the Factory

The average American farmer has two horses to aid him. The Italian farm averages one-fifth of a horse. The ratio of horsepower is therefore 10 to 1 in favor of the American farmer. What is the result? The average American farmer produces 7 times as much as does the average Italian farmer. In general, if the horsepower per farmer is increased 100 per cent, the output is increased 70 per cent.

And now comes the tractor not merely to replace the 21 million horses and mules on American farms but to increase the horsepower used. There are approximately 700,000 tractors on American farms with a combined horsepower that is probably about half that of all the horses and mules. But since a horse can exert, for a few minutes, six times his average tractive power, it is not equitable to compare tractors and horses without making some allowance for this fact.

The number of American tractors produced in 1925 was almost 170,000, of which about 120,000 were sold in America. Of these about 100,000 were sold to farmers. Even at this rate,—another decade will see nearly all the farm horses replaced by tractors. It is estimated that 10 years hence there will be 2 million tractors on American farms, which seems like a very conservative estimate. The cost of operating with tractors instead of horses on farms is estimated to be one-half the cost of operating with horses. Wheat and rice grown in America compete with those grains in China, in spite of the fact that American wages are 10 to 15 times higher than Chinese wages.

Three American farmers, by the use of machinery, can operate a 500-acre farm, and raise 8000 bu. of wheat in 6 mos. If as Henry Ford suggests, for the remaining six months two of these three men worked in a factory, the income of the average farmer might be almost doubled because his productivity would be almost doubled.

About one-quarter of all Americans in gainful occupations are farmers. With the increasing use of tractors and other farm machinery, it is evident that within a few years not more than one worker in ten will be needed to operate our farms.

In Russia, if we recall correctly, nine out of ten workers are farmers. Contrasting these two ratios in these two countries, what becomes of the old economic shibboleth: Farming is the basis of national prosperity.

The truth is that manufacturing and transportation have long been the basis of American prosperity, and now are on the eve of converting the very farms into highways and factories. With motor cars and tractors the American farmer is already a great transportation agent. With the wheat "combine," the "cornpicker and husker," the mechanical milker, and the like, the American farmer is already up to his middle as a manufacturer, and will soon be up to his eyes.

One of the economic curses of Europe is the small size of the farms, which makes it less economic to use tractors and other machines. And we in America are only partly free from the same curse of farm smallness.

The most economic American farms today are several times larger than the average American farm. Yet there is not only strong public opposition to increase in the size of farms, but even legislation is enacted to prevent the integration of larger farm units.

In Italy and France the American tourist is impressed not only by the numberless small farms but by the numberless small shops. People in those nations seem obsessed by the desire to be each his own boss. And what an economic mess they have made of it. The old saying has it that when a man is his own lawyer he has a fool for a client. It is equally true that when every man is his own employer he has a fool for a boss.

The income of the average salesman in Marshall Fields or John Wanamakers is three times that of the average shop proprietor in Italy or France, but ignorance and custom (which is usually ignorance petrified) keep those same little shop proprietors in a servitude that they fondly call independence.

Penetration of Wood Preservatives

The Two Methods Specified by American Association of State Highway Officials Compared in November Public Roads

By ROBERT I. RUDOLPH
U. S. Bureau of Public Roads

The specifications of the American Association of State Highway Officials for timber highway bridges require that the heads of the treated timber piles after having been cut to receive caps and prior to the placing of caps shall be treated to prevent decay. Two methods of treatment are specified. The first consists of three applications of a mixture composed of 60 per cent creosote oil and 40 per cent tar roofing pitch, and the second consists of three treatments with hot creosote oil after which the portion so treated is covered with hot roofing pitch. Tests have been made by the Bureau of Public Roads to determine the relative value of such treatments as to the depth of penetration into the wood.

Because of difficulty in procuring treated timber pile heads, the tests were made on wood blocks treated as specified by each of the two methods.

The wood blocks used for the purpose were approximately 6 by 6 by 12 in. in size and were made from a commercially known long-leaf, air-dried, dressed Georgia yellow pine.

The analysis of the tar roofing pitch was as follows:

Specific gravity at 25°/25° C.		1.264
Softening point		55°C.
Bitumen soluble in CS_2	per cent	74.86
Organic matter insoluble	do	24.98
Inorganic matter insoluble	do	0.16
Ductility at 25° C., centimeters		100+
Distillate up to 300° C.	per cent	4.49
Residue	do	95.31
Water		Trace.
Specific gravity of distillate at 38°/15.5° C.		1.043

The creosote oil showed the following analysis:

Specific gravity at 38°/15.5° C.		1.062
Insoluble in benzol	Per cent	.03
Coke	do	5.33
Water		None.
Distillate to 210° C.	per cent	0.70
210°-235° C.	do	8.66
235°-270° C.	do	26.43
270°-315° C.	do	27.39
315°-355° C.	do	20.43
Residue	do	16.00
Specific gravity of distillate (235°-315° C.) at 38°/15.5° C.		1.028
Specific gravity of distillate (315°-355° C.) at 38°/15.5° C.		1.084
Float test of residue at 70° C.	seconds	131

Mixture of 60 per cent creosote oil and 40 per cent tar roofing pitch:

Specific viscosity 40° C.	1.03

Before beginning the work it was decided to broaden the scope of the tests by treating separate groups of blocks by each of the two methods specified with cold and hot applications of preservative. Thus by the first method a group of blocks was treated with a cold mixture of creosote oil and tar and another group with a hot mixture of creosote oil and tar. By the second method one group was treated with cold creosote oil and another with hot creosote oil and the specimens of both of the latter groups were covered with hot roofing pitch. Each of the groups treated with preservative consisted of three wood blocks.

The preservative was thoroughly brushed on the end of the block and allowed to dry. The material applied hot was heated to a temperature of 70° C. The first application was fairly dry after 1½ hours and a second treatment was given. This coat took somewhat longer to dry and the third treatment was applied at the end of three hours. It was noticeable at the time of treatment that the creosote-oil applications seemed to be absorbed more readily than the creosote-oil and tar mixture. Tar heated to a temperature of 105° C. was applied two hours after the third application of creosote oil. The tar did not adhere readily to the creosoted surface and could not be brushed on. Therefore the hot tar was poured upon the treated ends and the entire surface was covered and smoothed over by means of a hot knife.

The tops of the blocks were sawed off 2 in. below the treated ends. These tops were then split at different sections and the average distance of penetration measured. The results of these measurements are given in Table I.

Table I.—Average Penetration of Preservatives Applied

Treated with creosote oil and tar mixture (cold)		Treated with creosote oil and tar mixture (hot)		Treated with creosote oil (cold), covered with tar (hot)		Treated with creosote oil (hot), covered with tar (hot)	
Block	Average penetration	Block	Average penetration	Block	Average penetration	Block	Penetration
	Inches		Inches		Inches		Inches
1	⅛	1	⅛	1	13/64	1	14/64
2	⅛	2	⅛	2	13/64	2	16/64
3	⅛	3	⅛	3	10/64	3	13/64
Average	⅛	Average	⅛	Average	3/16	Average	¼

Nearly all of the wood blocks had a small portion of sapwood at one of the corners. The blocks treated with creosote oil, either cold or hot, showed that the creosote oil had penetrated this sapwood for a distance in excess of 2 in. This was not so evident in the blocks

treated with the mixture of creosote oil and tar.

From the results obtained, it is apparent that there is no difference in the penetration of the blocks treated with a cold or hot mixture of creosote oil and tar. The blocks treated with creosote oil and covered with tar do show a greater penetration than was obtained with the mixture of creosote oil and tar. As between blocks treated with cold creosote oil and those treated with hot creosote oil, there is a slight difference in favor of the latter.

Concrete Pavement

A Suggested New Structure Designed to Lessen Cracking

By G. MAXON, JR.

The concrete paving industry has improved. The science of methods, the knowledge acquired by experience and experiment, the whole hearted interest of both the technician and the laiety, individually and thorough organizations have gradually eliminated the bad practices and brought to light new methods. However, imagine the experience when traveling over an old type concrete road to find it almost devoid of center cracks, practically free from new transverse failures and in better shape than a road traversed the previous day built three years later, that is, a year ago. Inquiring into the matter, we perused the reports on the Bates test roads, brochures from the Portland Cement Association, reports of the Government's Commission on Highway Research, text books, data from Universities, etc., and from no source was an explanation forthcoming. It seemed as though one road was the result of a happy coincidence of favorable location as to sub-grade and excellent workmanship and materials—and the other—the modern road—the reverse.

Don't think for a minute the above experience is an argument that the old type of roads are equal or superior to the modern; but consider this: 1st—There are no approximate engineering mathematics to lead us to believe the modern road is superior, and the high rate of deterioration begs an analysis which may lead to a definitely better structure.

Let us liken concrete roads laid on gravel, rocky well drained ground, or sand, to a strip of glass laid on an unyielding level surface. Heavy loads pass through it directly to the foundation. Fracture can occur only by shock or from internal stresses, such as shrinkage or temperature variation. Now, float the strip of glass on mercury or soft putty or wet soil. Direct loads will produce a flexure in the glass, and if the latter has a poor section modulus it will break. Even so do present day concrete sections fail when placed on clay or loamy sub-grade. The buoyancy of the subsoil may not be determinable but the distance between transverse failures, regardless of the type of sub-soil is a function of the moment of inertia of the cross section, as well as the loads applied. That function may be of the third, fourth, or fifth power, but there is a section for a given load where the moment of inertia is sufficient to resist failure. Why then should we break up this strip of glass into two strips when the section modulus of one half of the road is only one third of that of the entire road? The expectancy of more transverse cracks has been practically demonstrated. The cause of the center failure is mainly frost—frost which leaves that part of the sub-grade last where it penetrated to the greatest depth. The approximate center of the snow cleaned highway, elevated on a frozen pedestal—fails when Spring removes the frost from the edges, and because it fails we build it broken and thereby hasten the transverse failures.

Now, there are two ways of preventing these failures. One—to make the road so elastic that it will follow the movements of the sub-grade. The other, to make it so rigid that the subgrade will conform sufficiently to support it. Various combinations are possible. Wire mesh aid the former. Steel properly placed will aid in both directions. Nominally the section we have in mind would be so constructed that flexural loads would alternately be taken longitudinally and transversly by the reinforcement in the road. In such case the transverse steel would resist the loads from the frost pedestal and at intervals be hooked up with the longitudinal members. The steel would be of sufficient section so that no failure of itself alone would be likely to occur. Slightly deeper sections would contain the steel, while the balance of the road would not be as thick as now. No center joint would be incorporated, possibly transverse joints every 125 ft. to 150 ft. when weather conditions would indicate the need, and an omission of the steel when the subgrade conditions indicated uniform substantial support and good drainage.

This is the road we need—one to bridge over a given distance without support—one that is elastic enough to gain its support on poor sub-soils and a road we do not have to break into small pieces, knowing that every fracture is a time measurement of the road's ultimate failure.

Convention of Associated General Contractors of America.—The next annual convention of the Associated General Contractors of America will be held at Asheville, N. C., during the week of Jan. 24.

Black Base Pavement

Examples of Use of This Type for Specific Purposes Given in Paper Presented Nov. 9 at 5th Annual Asphalt Paving Conference

By HUGH W. SKIDMORE
President, Chicago Paving Laboratory, Chicago, Ill.

During the season just closing, several black base projects have been laid under our own supervision. Mention of these will show a few of the many ways in which black base may be utilized to advantage in accomplishing a very definite purpose.

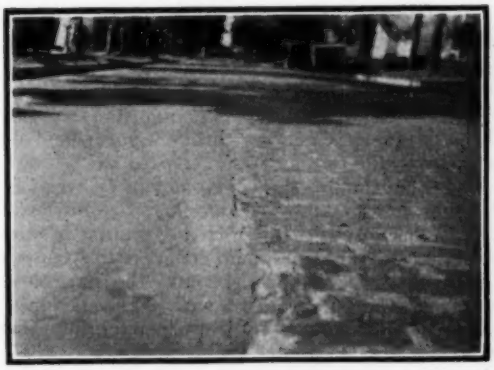
Widening Old Pavement.—In Hennepin County, adjacent to the City of Minneapolis, a section of old wornout portland cement concrete highway pavement on Minnetonka Blvd. was widened by means of black base and then the whole covered with a minimum depth of 1½ in. binder, followed by 2 in. of coarse aggregate asphaltic concrete.

Black Base Widening of Portland Cement Concrete and Surfacing with Binder and Top on Minnetonka Blvd., Hennepin County, Minn.

At Kohler, Wis., a portland cement concrete pavement was widened by constructing alongside thereof a strip of black base 4½ in. thick and 1½ in. sheet top.

In St. Joseph County (South Bend), Indiana, the Edwardsburg Road which consisted of a narrow gravel roadway, was widened out last year by means of a waterbound macadam and this summer the whole was covered with black base and sheet asphalt top. In some respects the work was quite similar to that being done in Michigan, especially with respect to laying the base 2 ft. wider than the top, thus providing reinforcement of the edge against possible lateral displacement. This is considered very effective and economical treatment of the edge, which generally requires some sort of special design to take care of the thrust of traffic along the outer edge of narrow pavements (18 ft. being classed as narrow in these days of super-highways).

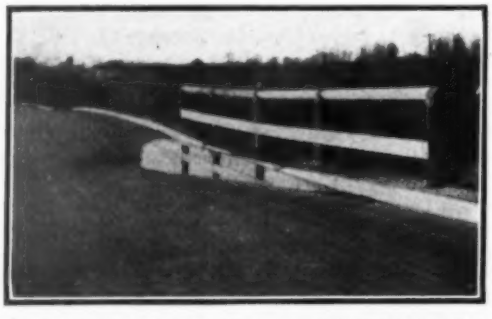
Pavement on Unstable Subgrade.—During 1924 and 1925 about 100,000 sq. yd. of 4½ in. black base with 1½ in. sheet top was laid on native clay and loam subgrade in Quincy, Ill., under our supervision. The base mixture on this work was extremely dense, by virtue of using a well graded crushed rock coarse aggregate, from 2½ in. down, in size. In every instance this base was laid in one course directly upon the natural subgrade and in some cases the nature of the soil made construction difficult in wet weather, but perhaps no more so than would have been the case with any other type of base, except possibly in the Aldo Boulevard district, which had formerly been a nursery and the soil was "made" for this purpose. It was so sponge-like that some hardship was experienced in two blocks of pavement owing to the difficulty of rolling the base and top on the quaky soil. In this particular case the unstable subgrade should have been covered with a layer of gravel or broken stone, but under the Illinois law governing special assessment work, it is impossible to introduce an extra of this kind without endangering the legality of the project. Once the pavement was laid however, no further trouble developed.



Brick Pavement on Lincoln Highway at La Porte, Ind., Widened with Black Base and Sheet Top

In connection with one of the pavements laid in 1924, viz., East Broadway, black base

was chosen in preference to a rigid base because a sewer had just been laid down the center of the street, and since the soil was clay, it was almost certain some settlement would occur. The city engineer (W. P. Bushnell) felt that if such settlement did take place, repairs to a black base pavement would be much simpler than with portland cement concrete, as the bituminous concrete would eventually follow the subgrade, and a surface patch in the topping would restore the uniformity of contour. A few such areas did subside very slightly. These Quincy pavements, including grading, cost from $2.25 to $2.55 per square yard.



Black Base and Sheet Top on Heavy Fill on Nelson Park Road, Decatur, Ill. Note Settlement without a Crack in Pavement

Another example of deliberately taking advantage of this same virtue of flexible base was in the case of the approach to a bridge on Nelson Park Road (East Wood St.) at Decatur, Illinois, in 1923. Black base was selected for paving the bridge approach over a heavy fill (which was known to be still settling) although the remainder of the project leading to the approach employed a Portland cement concrete base. Heavy rains in the fall and spring following construction caused under-cutting at the edges and the pavement followed the subgrade down. These depressions were removed by simply applying new mixture to the surface in the usual way.

Speed Limits in Cities

Establishment of minimum as well as maximum speed limits as the next step in the battle to relieve the growing congestion of street traffic in American cities is forecast by the Albert Russel Erskine Bureau for Street Traffic Research. While condemning excessive speeds even under favorable conditions as well as malicious disregard for safety on the part of the automobile driver, the Bureau cites the 10 mile an hour "dragger" on a 20 mile an hour traffic artery as the cause of traffic delays and in some cases serious accidents.

"Uniformity of speed is a highly important factor in regularity of traffic, for only regularity and smoothness of flow insure the volume of movement which must be attained in view of the increasing flood of motor vehicles on the restricted street area of most American cities," says Miller McClintock, director of the Erskine Bureau, which was endowed this fall in Harvard University for scientific study of street traffic congestion.

"Drivers who insist on holding up traffic to a snail like pace of 5 or 10 miles an hour on important streets should be subject to a certain amount of legal prodding. When streets are filled with vehicles the slow driver regulates the speed of all following traffic and by his selfishness or carelessness often delays hundreds. Slow drivers are also the unwitting cause of many accidents by making it necessary for overtaking motorists to cut into the opposing traffic stream to pass."

Mr. McClintock points out that somewhere between the excessively slow driver and the dangerous speeder is the middle ground of sensible traffic flow, and to determine this middle ground is one of the tasks of the traffic engineer.

Surveys of the principal American cities indicate that in placing limits on speed, legislators have almost always fallen short of current demands for rapidity of movement. While based on a sound principle of safety, most of the speed regulations now on the statue books have been antiquated for ten years.

In discussing this question of maximum and minimum speed laws, Mr. McClintock points to the results of the Metropolitan Street Traffic Survey recently completed in Chicago, which disclosed a typical case of obsolete speed laws. Maximum rates specified by the state are eight miles an hour at obstructed corners, ten miles an hour in closely built up portions, fifteen miles in residential districts, and twenty miles an hour outside the closely built up portions and residential districts of towns and cities.

"These restrictions," says Mr. McClintock, "were obsolete ten years ago, yet Chicago is technically governed by them. Their chief service is to permit technically inclined public officials of some of the small cities in the Chicago region to levy unwarranted toll on the motoring public."

One of the recommendations in the Survey's report on Chicago's traffic congestion urged that the state legislature take steps to permit the city to place minimum speed limits on all or part of its streets. It was suggested that these limits be 50 per cent of the maximum permitted in any district.

Effective Hot Mix Pavements

Essential Construction Details Discussed in Paper Presented Nov. 11 at the 5th Annual Asphalt Paving Conference

By FRANCIS P. SMITH

Dow & Smith, Chemical and Consulting Engineers, New York City

The art of laying hot mix pavements has been developed in this country during the past 50 years. Like most arts with a life history of similar length, it has made great strides, has been confronted with changing conditions and has been hampered with bad habits and traditions acquired during the early period of its existence.

For the first 40 years it had to meet the problem of producing a pavement which would successfully carry a slow moving iron tired traffic of light to moderate intensity. During the last 10 years the density and speed of highway traffic has increased beyond the wildest dreams of human imagination a decade ago and iron tires have been almost entirely replaced by tires made of rubber. This change in the character of the traffic carried by our roads and streets calls for a pavement possessing the same general characteristics as those of the earlier type but with a marked change in their relative value and importance. Methods of manufacture have also been changed and improved and the daily output of single plants has been greatly increased.

Some of the qualities of a hot mix pavement are inherent in the mixture itself and are fundamentally therefore questions of design. These questions will be covered by others at this meeting. Other qualities involve design, manufacture and laying methods, while still others are functions of the last two only.

It is the purpose of this paper to discuss the necessary qualities and the best methods for securing them, except those which are solely questions of design.

What Effective Life Depends On.—The effective life of a modern hot mix pavement is largely dependent upon:

1. The quality of the mixture.
2. The uniformity of the pavement as to:
   (a) Composition
   (b) Thickness
   (c) Density
3. Contour of the finished pavement.

Of equal, if not greater importance, are the kind and character of the foundation, subsoil and drainage but these have been considered by the speaker as falling outside the limits of this paper.

In the earlier days much less attention was paid to these details than is now necessary. The factor of safety was much greater because much less was required of the pavement and this inevitably led to more or less careless work and the acquired habit is hard to shake off. Old time superintendents and foremen are inclined to jeer at extreme precautions and class them as "old fogeyism" utterly failing to realize that they themselves are the "old fogies."

The strain of modern traffic is so terriffic that it calls for the exercise of the most skillful workmanship to enable even the best of materials to withstand it and this is true of every type of modern pavement. In most instances it costs no more to lay a pavement in accordance with the best modern methods than it does to lay it carelessly. The importance of these factors from the standpoint of competitive design and maintenance costs, cannot be too strongly stressed.

Quality of the Mixture.—The quality of the mixture is dependent upon its design, the character and uniformity of the materials entering into its composition and the methods of manufacture employed. Eternal vigilance is necessary to insure uniformity and quality of deliveries of raw materials to the plant. The chief variation is found in sand and stone deliveries. If these vary to any great extent, it is impossible to make a uniform mixture out of them. The product of stone quarries and sand pits is far from uniform. Major variations in mesh composition, even if within specification limits call for variations in bitumen and dust contents of the mixture. If the formula remains unchanged, the mixture will vary markedly in physical characteristics and uniformity will be lost even if quality is not impared. Dirty stone or sand after passage through the drier frequently has fine dust partly baked on the outer surfaces of the larger grains or particles. This seriously interferes with the proper and permanent adherence of the bitumen coating and materials of this type should be rejected.

Temperature Control.—Adequate temperature control is essential to prevent injury to the bituminous binding. This applies not only to the heating of the bituminous material but also to the heating of the mineral aggregate.

Stone or sand which is too hot will damage the bitumen more seriously in a short time than hours of moderate overheating in a large kettle. In order to secure proper bond between the bitumen and the aggregate all moisture must be driven out of the aggregate and it must be heated to the correct temperature to facilitate mixing and insure delivery on the work at such a heat as will be most favorable to laying and compression. Too low a temperature increases the difficulty of properly and uniformly coating the mineral aggregate with bitumen and makes a mixture which is difficult to rake on the street and impossible to compress effectively. Varying percentages of moisture in the aggregate call for variations in drum temperatures which must be carefully watched. Electrical pyrometers if properly used not only indicate temperatures but are of great aid to the fireman and result in increased output as well as necessary uniformity of mixture. Notwithstanding this, the speaker has had their installation bitterly opposed by foremen for the reason that they would seriously curtail the plant output! The logical deduction to be drawn from such an argument is too obvious to require further comment. Undoubtedly the future will see the widespread development of automatic thermostatic control.

Careful Mixing Important.—Mixer teeth in good condition, shafts operating at proper speed and sufficient time given to mixing are extremely important. The mineral aggregate must be evenly, uniformly and completely coated with bitumen. Too often mixer teeth that are half worn down are kept in service and the time of mixing reduced to increase the output. This results in a mixture in which some of the particles are imperfectly coated with bitumen and some parts of the mixture are excessively rich at the expense of other portions which are too lean. Such a mixture is especially liable to wave under heavy traffic.

Thorough adherence of the bitumen to the mineral aggregate is greatly increased by the sustained attrition of the particles for an appreciable period of time. The principle is the same as that involved in thoroughly brushing out the coat of paint applied to a surface for protective purposes. It is absolutely essential that the film of bitumen should be strongly adherent to enable it to successfully resist water action, weathering and the movement of the particles of the mineral aggregate under traffic stresses.

Importance of Uniformity of Composition.—Uniformity is perhaps a greater aid toward retarding wave formation than is generally recognized. A pavement in which soft rich spots occur surrounded by a notably harder mixture is much more liable to form objectionable waves and lumps than one which is uniformly soft. In the latter case the displacement will be less localized, i. e., will be distributed over a larger area, and will have a tendency under certain conditions to heal under traffic which will be noticeably absent in the former case.

Uniformity of composition is largely a matter of plant control. It is dependent upon uniformity of raw materials (chiefly mineral aggregate) accurate weighing and thorough mixing. If any of these are slighted a non uniform pavement will result. Another source of danger is segregation during transit between plant and street. The coarser aggregates are particularly liable to this, more especially if they are poorly graded and lacking in intermediate sizes of stone, particularly ¼" and ½" particles. Most specifications are very lax or indefinite in their requirements as to the amount of ¼" material which the mixture should contain. When mechanical spreading is employed it is difficult to correct segregation. With hand spreading it is possible to correct it by turning the mixture over with shovels before putting it in place and this should always be done in the case of coarse aggregate wearing surface. It is perhaps unnecessary with binder except in extreme cases. The appearance of the average binder course after laying, especially where intermediate sized stone is absent, plainly shows the extent to which segregation takes place in coarse aggregates during transit.

Suggestions on Raking.—Uniformity of thickness is chiefly dependent upon the grade of the finished base and the care exercised in raking. It used to be almost an axiom in the bituminous paving industry that any errors in the grade of the base would be remedied by the binder and these in turn by the top and as it was desirable to have the surface of the concrete or other base rough in order to prevent the bituminous mixture from sliding on the base, this precluded the possibility of laying it accurately to grade. This fallacy led to a widespread disregard of the contour and grade of the finished base which is all too prevalent at the present time. It would appear to be axiomatic that a bituminous wearing surface of greatly varying depth is more liable to displacement under heavy traffic than one of uniform thickness and yet it is very difficult indeed to convince engineers of the necessity of fine grading their concrete foundations. The speaker at times feels like advocating the use of a template or paving gauge on both the foundation and the finished surface. Roughness of surface should be made subordinate to maintaining grade and can be obtained by the use of corrugated rollers, vibrating mats or similar devices.

The raking of the hot mixture is usually done by eye. Here again a gauge would be an improvement. It takes many months to make

a good raker out of a man who is fitted for the work and many men never become good rakers. In former days when the plant output was less than at present and horse drawn wagons delivered the hot mixture on the street, there was sufficient interval between the loads for the head raker to go over the work of the other rakers and correct their errors. To-day this is rarely done. There is no time available and in the speaker's judgment there are fewer good rakers, or possibly the demand for them has increased, which amounts to the same thing as far as any one job is concerned. The use of a long handled screed 4 ft. to 5 ft. in length operated at right angles to the direction of raking after the raking is completed will correct many of the errors of poor raking. Careless methods of spreading or too small a street gang to handle the plant output frequently necessitates standing in the hot mixture. This inevitably causes variations in thickness unless the mixture where trampled upon is "fluffed" up to the same density as the balance of the mixture by the rakers. With a stiff mixture this is hard work and rakers will not do it conscientiously and thoroughly all day. With the plant pushing the street gang to the limit of their capacity to do good work, this will inevitably happen. The remedy is to increase the street gang but with a narrow roadway this cannot be done beyond a certain point.

Producing Ultimate Composition by Rolling.—The density of a pavement is dependent upon its design and the amount of compression it receives. In order to secure maximum stability it is essential that rolling should be applied and continued in such a manner as to produce as nearly as possible, ultimate compaction. Here again tradition hampers, for in former times areas which were not fully compressed when the pavement was laid received their final compaction under traffic and in most cases no great harm resulted. The danger of such a practice is increased one hundred fold to-day. Inadequate roller equipment is all too common and the fault is partly due to lack of realization of what is necessary to properly handle the large output of modern plants. Increasing the speed of the rollers decreases their compressive effectiveness and tends towards faulty contour. More rollers are required and must be used and they must be kept continually in operation. The delays incident to cleaning fires and filling up boilers with water have led many contractors and county organizations to turn to the motor roller. The clutch mechanism of this type of roller has recently been greatly improved but it is absolutely necessary to maintain it in perfect condition otherwise the jerks incidental to starting and reversing will be fatal to good contour.

Dense modern mixtures require the use of a heavy roller for initial rolling. After such mixtures become slightly chilled it is impossible to effectively compress them. Twelve and fifteen ton three wheel rollers are being increasingly used for this purpose instead of the former five to eight ton tandem roller. They should be put in use just as soon as the freshly raked mixture will take them and no delays should be tolerated. This precaution is especially essential in cool weather.

Effective raking is a necessary adjunct to effective compression and a close inspection of the surface after the first rolling clearly shows this. If the raking is poor, the surface of the freshly rolled mixture will show a number of honey-combed spots. These are due to the fact that the full weight of the roller has not been applied to them because it has been chiefly supported by adjacent humps. These humps must be displaced before the low spots can receive proper compression and that means that more rolling will be necessary and if the humps are large and—or the street is too narrow to permit diagonal rolling, it is questionable whether uniform density will ever be obtained through rolling.

When the pavement is subjected to traffic, these partially compressed areas may, under favorable conditions, receive final compaction. If they do not, they will probably ravel out sooner or later, leaving a hole. If they do, a slight depression will be formed, which under heavy traffic and unfavorable conditions, will diminish the effective life of the pavement and increase its tendency to wave. Uniform density of the finished pavement calls for good workmanship at every stage and slackness or inefficiency in any one operation can only be remedied, if at all, by increased labor and expense in the subsequent stages.

Securing Uniformity of Contour.—Under former conditions extreme smoothness of contour was not essential. If there were no low spots which would hold water, it was considered satisfactory and no discomfort was experienced in riding over it at the maximum speeds prevalent at that time. Unevenness of contour to modern high speed traffic means discomfort and if extreme, danger and greatly diminished life. A comparatively small depression starts up spring vibration and enormously increases the force of impact which is so destructive to all our modern highways. It also localizes the point of impact and this results in progressively increasing it to a point where no type of construction will withstand it.

Once more eternal vigilance is the price of uniformity of contour. A straight edge should be continuously used to check up the contour after the first rolling, at which time serious defects are most easily and cheaply remedied. The screed previously mentioned, if properly used acts as a short preliminary straight edge which is easily and quickly applicable to any

doubtful spot at the time when the defect can be remedied with maximum ease and effectiveness.

The careful leveling of joints must be given close attention if uniformity of contour is to be maintained but this is secondary in importance to good workmanship in raking and rolling for the reason that the joints occur only infrequently.

Cardinal Principles.—In conclusion the speaker would urge recognition of the following facts and cardinal principles:

1. That in all types of highway construction whether of portland cement or bituminous concrete the factor of safety and the inherent qualities of the mixtures used are such as to imperatively require the best grade of honest and efficient workmanship.

2. Foundations must be adequate and no foundation can be commercially adequate without proper provisions for drainage.

3. The slighting of any of the stages of construction work with the idea of remedying it later on is expensive and inadequate and cannot produce a satisfactory result. This applies especially to the strict adherence to established grades for the various portions of the pavement.

4. Apart from design, uniformity of mixture, density and contour are the three most essential points.

5. Plant: Test all materials delivered—control temperatures and mixing periods—accurately proportion ingredients and bend every effort towards sending out uniform mixtures.

6. Street: Insist on proper spreading, raking and rolling and adequate equipment and number of men. Require strict adherence to established grades for the various courses of the pavement with special attention to the final surface.

Night Traffic Counts.—Observing that motorists are using the highways more and more for night driving, Division VI of the California Highway Department during last July made counts at five stations in the San Joaquin Valley to determine the percentage of traffic using the highways for the eight hours from 10 p. m. to 6 a. m. as compared with the total for the 24 hours. It was found that the night traffic, that is, the count from 10 p. m. until 6 a. m. totaled 16 per cent of the whole or double what it was in 1922. In view of the fact that this count was taken during the warmer weather in the San Joaquin Valley, it may be that the same percentage would not hold for all sections of the state. Nevertheless it is evident to observers that night driving, especially the move of trucks, is on the increase.

Railroad Retrieving Traffic Losses with Motor Coaches

In the territory served by the New York, New Haven & Hartford R. R. competitive highway coaches cover annually 1,500,000 miles in New York State, 20,000,000 miles in Connecticut, 7,000,000 miles in Rhode Island and 15,500,000 miles in Massachusetts, as disclosed by a survey made by the railroad. To these figures must be added 48,000,000 miles of inter-state motor coach operation each year. This total of road miles operated in revenue service reflects a loss in revenue to the railroad each year that is estimated at about $27,900,000, said A. P. Russell, vice-president of the railroad company, in an address at the transportation and service meeting of the Society of Automotive Engineers in Boston in November.

To prevent further loss and retrieve as much as possible of the traffic that had been diverted, the railroad last year applied for and was granted authority to operate vehicles on the highway. It then organized a subsidiary company, known as the New England Transportation Co., to operate motor coaches.

"Early in August, 1925," said Mr. Russell, "we installed our first line, in lieu of train service, on a branch in western Connecticut, with the result that a considerable saving over train service was effected. We found that we were substituting a means of transportation that cost substantially 30 cents per miles in place of one that might average nearly $1.25. From then on we proceeded with great care in an endeavor to find what would checkmate the enormous shrinkage in passenger revenues due to the operation of trains that were not earning their operating costs. Gradually more and more lines were added until the summer of 1926 found us operating 37 routes and utilizing 168 motor coaches. Almost one-half of these routes take the place of train service.

"These coaches make about 438,000 road miles per month and carry approximately 235,000 passengers. The average length of the routes is 28 miles; the shortest being 3; the longest, 60 miles. Our operating cost per mile can conservatively be said to be 30 cents.

"In establishing our schedules we have paralleled as nearly as possible the railroad schedule, in many cases offering extra trips to eliminate double-heading. Aside from providing a regular schedule, we have endeavored to give slightly more service. As a general thing, we reach places that have not had what might be considered satisfactory rail service and are regaining travelers who had sought other means of transportation."

Repair Costs of Rural Pavements

Data for Highways in Cuyahoga County, Ohio, Given in Paper Presented Nov. 9 Before American Society for Municipal Improvements

By FRANK A. THOMAS

City Engineer of Euclid, O.; Former Paving Engineer of Cuyahoga County.

At the 1925 meeting of this society, Mr. Simpson, City Engineer of Columbus, O., read a paper on the "Repair Costs of City Pavements."

This paper that I am reading today is a similar one with the exception that the pavements are rural.

City pavements are seldom less than 24 and up to 60 ft. or more in width. Curbs are raised, with an exposed face 4 to 8 in. above the surface of the pavement. Catch basins and sewers take care of surface drainage.

Rural pavements referred to in this paper, are from 8 to 20 ft. wide, with flush curbs, and open side ditches to take care of surface drainage.

These rural pavements on which repair costs are herein quoted are located in Cuyahoga County, Ohio, of which Cleveland is the county seat.

When I say "rural pavements," I refer of course to pavements that were considered rural when they were designed and constructed. Cuyahoga County built its first rural pavement in 1896. This county was a pioneer in rural highway improvement and had most of its main arteries leading out of Cleveland, either partially or entirely paved with brick by the time other progressive communities of the country were beginning to think along these lines.

Cuyahoga County's leadership in this respect was so pronounced that in the earlier days, when the advent of the automobile brought the need for improved highways so forcibly to our attention, engineers and officials from all parts of the country, as well as from foreign countries, came to Cuyahoga County to study its pioneering efforts.

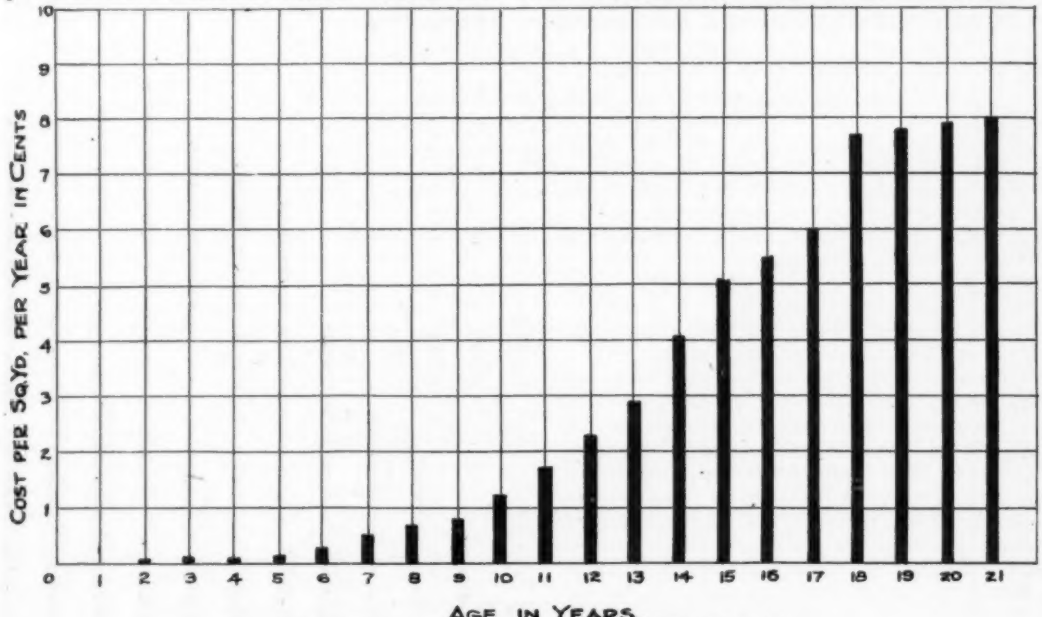


Fig. 1—Repair Costs of All Brick Pavements from Ages 1 to 21

Some of these early pavements are still in service, but actually several of them are no longer rural pavements. We find them the main business streets in thriving communities that have developed along the county's main arteries. We find them carrying the very heaviest city traffic in addition to the through traffic. In some cases they have been widened, with the old pavement still doing service either in the center or at one side.

This condition brought about by the very rapid growth of Cleveland must be taken in consideration when anlyzing the maintenance data contained in this paper.

The Earlier Pavements.—The first pavement built in 1896 was only 8 ft. wide. It had a 4 in. vitrified brick, cement grout filled surface, laid on a 1 in. sand bedding course. The base was of broken stone 6 in. deep. The curbs were of sandstone 4 in. wide and 16 in. deep, set flush with the brick surface.

Between 1896 and 1903 several of these 8 ft. pavements were built, one of which is still in service. Though of ancient design, it still carries modern traffic.

In 1903 the standard width was increased to 14 ft. and in 1909 the type of base was changed to concrete. The concrete was a 1:2½:5 mix and 4 in. thick. Concrete curbs were used generally from 1909 on, but not exclusively.

I have said that our stone bases on these early pavements were 6 in. deep and our concrete bases 4 in. deep; and of 1:2½:5 mix. Perhaps I should add a word here concerning the strange phenomenon noticed within the last few years.

In repairing some of these pioneer pavements we have found that, in some instances, part of the crushed stone or the concrete as the case may be, has entirely disappeared. As much as an inch or two seems to have been entirely absorbed or in some manner dissipated. Six inches of stone some times has shrunken to 4 in., and 4 in. of concrete to 3 in. or even 2 in. It is very strange.

Perhaps you have noticed this same phenomenon in your own respective communities, and perchance you have reached the same conclusion that we have been forced to, namely, that the builder in those bygone days was prone to make mistakes, or when he left his ruler at home, was a poor judge of base thickness.

In 1915 the concrete and macadam type of pavements were introduced and the width increased to 16 ft. In 1917 asphaltic concrete on a portland cement concrete base was first laid.

The monolithic brick type as well as brick with cement-sand bedding course was used on several pavements between 1915 and 1922. In 1922 the standard width was increased to 18 ft. In 1923 asphalt filler was substituted for cement-grout.

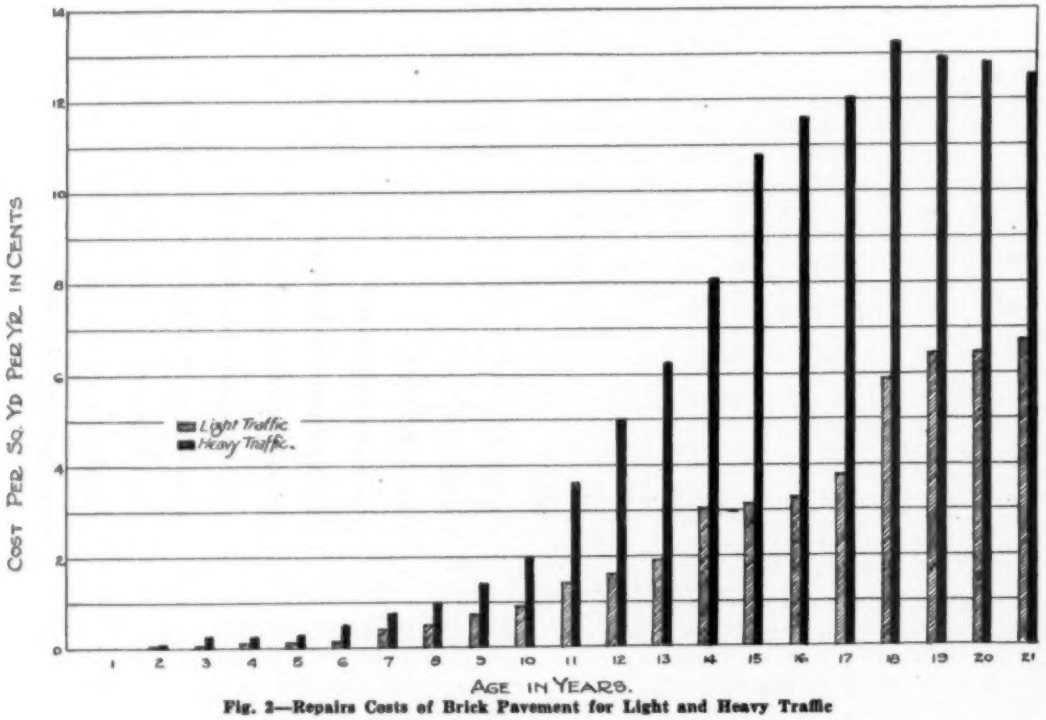


Fig. 2—Repairs Costs of Brick Pavement for Light and Heavy Traffic

This rural highway system has nearly 400 miles of pavement and is made up of 140 separate improvements.

There are four general types of pavements: Brick leads with a yardage of 2,058,399 or 65 per cent of the total; concrete with a yardage of 592,213 or 18 per cent; macadam with a yardage of 349,284 or 11 per cent, and asphalt with a yardage of 208,361 or 6 per cent.

The Brick Type.—The 4 in. paving brick was used on 96 per cent of the 2,058,399 sq. yds. and the 3 in. paving brick on the balance.

Cement grout filler was used on 91 per cent of the yardage and asphalt filler on 9 per cent. Plain sand or granulated slag cushion or bedding course was used on 87 per cent of the yardage, cement-sand 1:3 mix, on 3 per cent and 10 per cent was laid on the green concrete

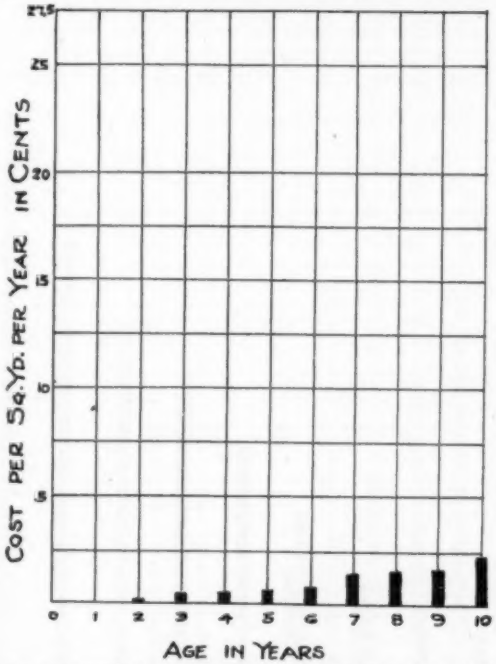


Fig. 3—Repair Costs of Brick Pavements from 1915 to 1924

base, making the so-called monolithic type. Of the total yardage, 18 per cent is on a 6 in. broken stone base, 63 per cent on a 4 in. concrete base, 7 per cent on a 5 in. concrete base, 4 per cent on a 6 in. concrete base, 7 per cent on a 7 in. concrete base and 1 per cent on an 8 in. concrete base. Steel reinforcing was used on 12 per cent of the concrete base yardage. (I prefer to call it steel "binding" because it was so light that it did not amount to much as reinforcing.) Stone curbs were used on 25 per cent and concrete curbs on 75 per cent of the yardage.

Figure 1 shows the repair cost per square yard per year for all brick pavements. The costs are the average of all brick pavements, regardless of the type of construction or location, and cover an experience of 21 years in rural highway paving in a rapidly growing locality.

It will be noted from this graph that the repair cost is low and rises gradually for the first ten years, after which it rises rapidly, and in the twelfth year it has doubled; in the fourteenth year it has quadrupled and in the eighteenth year it is nearly eight times as much. After the eighteenth year it runs uniformly for the next three years.

It must be remembered in considering this rapid increase in repair costs after the first ten years, that the writer is referring to pavements designed and built before even the most visionary engineer could intelligently forsee the enormous traffic they would be called upon to carry. It is noted that this period of sharp rise in repair costs starts at about the time that the gasoline motor brought to our streets and highways, an intensity and weight of traffic never anticipated by the engineers who designed them.

Figure 2 shows the repair cost per square yard per year for brick pavements carrying light and heavy traffic, respectively The heavy black is for light traffic and the hatched for heavy traffic.

The decision as to which are heavy or light traffic pavements was made by the writer from personal knowledge and from whatever traffic data were available.

Figure 3 shows the repair cost for only those brick pavements built between 1915 and 1925. This graph is made to enable a fair comparison with other types built in the same period. No other type but brick was built previous to 1915.

Figure 4 shows the repair cost for brick pavements built on a 4 in. concrete base.

The repair costs given in this paper are for slab maintenance only. They were determined by taking the amount of money spent for repairs on the several improvements each year and dividing that amount by the total yardage in service during each year. The result was the repair cost per square yard for each year. The cost per square yard per year is the quotient of the accumulated amount of money spent for repairs on any period of years, divided by the number of years in that period.

As an example, there were 2,058,399 sq. yd. of brick pavement that were in service one year, on which nothing was spent for repairs, making the cost per square yard for the first year nothing. There were 1,898,227 sq. yd. that were in service two years, on which was spent the sum of $2,753, making the cost per square yard for the second year 14 hundredths of a cent. There were 1,875,359 sq. yd. that were in service three years, on which was spent the sum of $4,222 during the third year, making the cost per square yard for the third year, 22 hundredths of a cent. Now the accumulated cost per square yard for three years is the sum of nothing for the first year, 14 hundredths of a cent for the second year, and 22 hundredths of a cent for the third

year, or a total of 36 hundredths of a cent. The cost per square yard per year for a three year period would be 36 hundredths of a cent divided by three, or 12 hundreths of a cent.

Remarks on the Brick Type.—On 1,524,640 sq. yd. the repair cost for ten years was 12½ cts. a square yard, or 1¼ cts. per square yard per year.

On 1,073,342 sq. yd. the repair cost for 13 years was 38 cts. a square yard or 2.9 cts. a square yard per year.

On 680,253 sq. yd. the repair cost for 15 years was 75 cts. a square yard or 5.1 cts. a square yard per year.

On 112,719 sq. yd. the repair cost for 20 years was $1.60 or 8 cts. a square yard per year.

One-half of the total repair cost was spent on these pavements of early design, built between 1904 and 1909. Much of this cost has come with the unexpected heavy traffic. These pavements have a non-rigid base of broken stone 6 in. thick and the yardage is 18 per cent of the total.

Two-thirds of the total repair cost was spent on seven roads having less than 20 per cent of the total yardage. These were, of course, the heaviest traveled of the brick roads, our main arteries. The repair cost on these seven roads equals 90 per cent of their initial cost. One-half of the total repair cost was spent in the twelfth, thirteenth, fourteenth and fifteenth years.

Several of the old brick pavements this year (1926) are being reconstructed by widening and resurfacing, and in these cases it is possible to determine a salvage value, and the total pavement cost per square yard per year of the pavement.

One pavement in particular is being resurfaced with asphaltic concrete. The original cost of the old brick pavement was $1.81 a square yard. It has given 20 years of service with a repair cost of $1.60. The interest for 20 years at 5 per cent is $1.81, making the total cost $5.22. The salvage value or the worth of this old pavement as a base is at least $1.75. The net cost will be the difference or $3.47 for 20 years of service or 17.4 cts. a square yard per year. At this rate an 18 ft. pavement would cost less than $2,000 a mile per year.

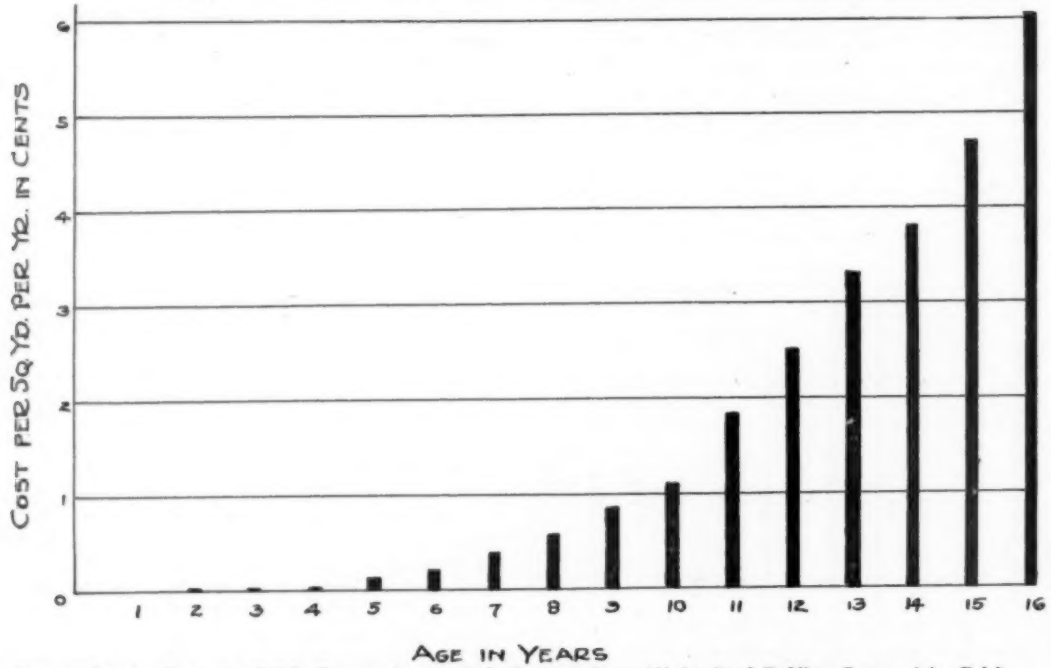


Fig. 4—Repair Costs on Brick Pavements on 4 in. Concrete Base, 1½ in. Sand Bedding Course, 4 in. Brick Surface with Cement Grout Filler

The pavements that required the most repairs were the heaviest traffic routes, on clay soils, which had a low supporting value. Faulty drainage undoubtedly was the major cause of many of the repairs.

The average original cost per square yard for all brick pavements was $2.50. The average original cost per square yard for brick pavements built between 1915 and 1925 was $3.42.

Since two-thirds of the brick yardage was built prior to 1915 on a 6 in. broken stone or 4 in. concrete base, only 14 ft. wide, and designed primarily for horse drawn vehicles, these brick pavements have a very reasonable repair cost.

The brick pavements built between 1915 and 1925 have a lower and more uniform repair cost than the other types of pavements.

In Cuyahoga County, pavements have been financed by 10-year bonds and any pavements

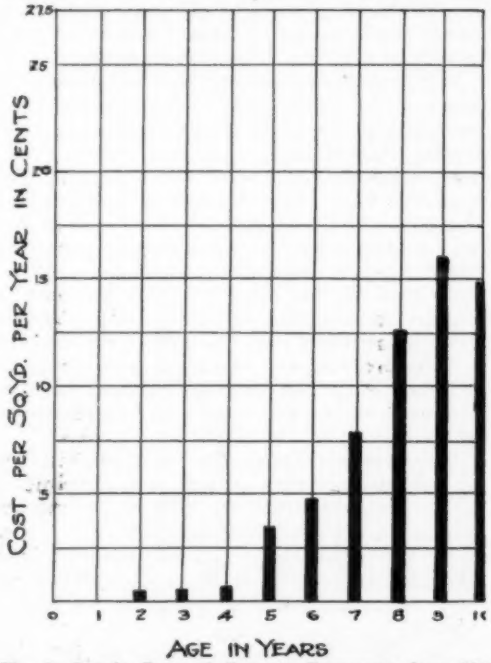


Fig. 5—Repair Costs of Concrete Pavements from 1915 to 1924

that require excessive repairs during this period may justly be considered as a failure. There has been no failure in the brick type.

There is no doubt but what the grout filler in the brick surface added greatly to the strength of these old pavements with thin weak bases, and was one of the reasons why they stood up so well.

The Concrete Type.—The first concrete pavement was completed in 1915 and from this time to 1925, a total of 592,213 sq. yd. have been laid. Several different designs were used. About 60 per cent of the yardage was laid in two courses and 40 per cent in one course. The first course in the two course jobs was of a 1:2½:5 mix, except one job which had a 1:2:4 mix. The second course was a 1:1½:2½ mix on about one-half of the two course yardage and a 1:1:2 mix on the other half.

All of the two course jobs were laid on a flat subgrade and were 6 in. thick at the sides and 8 in. in the center, except two jobs which were 7½ in. at the sides and 9½ in. in the center. Several of these two course jobs had 8 in. by 10 in. concrete beams reinforced with 2½ in. square bars under the edge at each side of the slab.

The one course jobs are all 8 in. thick and of 1:1½:3 mix. Reinforcing steel was used on all jobs except two. The concrete roads are 16 to 18 ft. wide.

Figure 5 is a graph showing the repair cost per square yard per year.

Remarks on Concrete Type.—Because much of the concrete yardage in the county has not passed through what might be termed the critical period, the writer purposely refrains from drawing any definite conclusions. Generally speaking, but with some few exceptions, the concrete pavements all located on secondary roads, have stood up fairly well. One pavement was a complete failure, and the cost of repairs on this one job was much

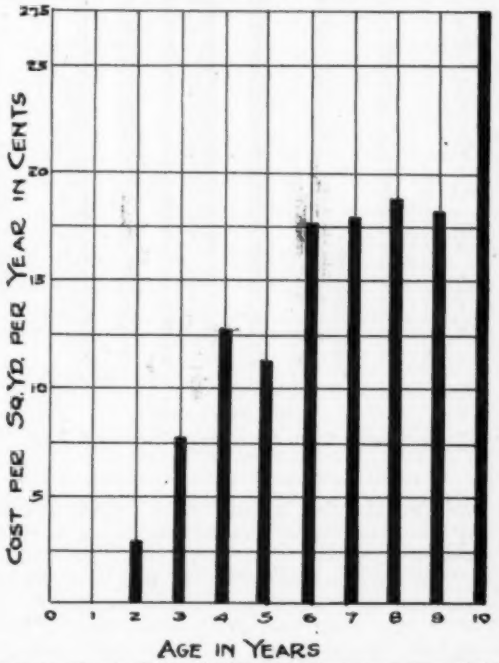


Fig. 6—Repair Costs of Macadam Pavements from 1915 to 1924

more than its original cost. This amounted to 80 per cent of the total repair cost of all concrete roads. The yardage of this pavement was about 4 per cent of the total.

The pavement had a flat surface on the subgrade and was 6 in. thick at the sides and 8 in. in the center. It was built in two courses, the first course being a 1:2½:5 mix and the second a 1:1:2 mix. The subgrade soil, as is the case under many of our pavements of

whatever type, was a heavy clay with poor drainage. This poor drainage was a major cause of failure. The average original cost per square yard for all concrete pavements was $3.00.

The Macadam Type.—The macadam type of pavement was first used in 1905, and between this date and 1925 there were nineteen roads improved with this material.

Of the 349,284 sq. yd., 40 per cent was built in two courses and 60 per cent in three courses. The top or surface course on 70 per cent of the yardage had a bituminous binder applied by the penetration method, tar being used on nearly all jobs.

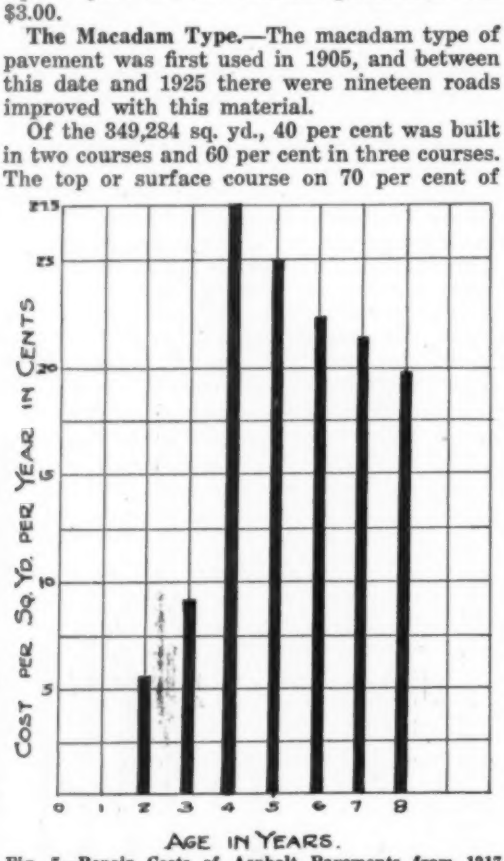


Fig. 7—Repair Costs of Asphalt Pavements from 1917 to 1924

The surface course on 30 per cent of the yardage was water-bound, and practically all of it has been surface treated with a bituminous material one or more times since it was placed in service. Crushed slag was the aggregate used on all the jobs.

The first course was 5 in. thick on all jobs except three, on which it was 4 in. The second course was 5 in. on the two-course water-bound, 3 in. on the two-course penetration and 4 in. on the three-course jobs. The third course was 3 in. thick.

The macadam roads are 16 to 18 ft. wide.

Figure 6 is a graph showing the repair cost per square yard per year for all macadam pavements.

Remarks on Macadam Type.—Twenty-eight per cent of the total cost of repairs was spent on one improvement.

Sixty per cent of the total cost of repairs was spent on 94,772 sq. yd., which is less than 30 per cent of the total yardage. This 94,722 sq. yd. has been in service 5 to 10 years.

Judging from Cuyahoga County's experience, repair costs equal first cost at the age of ten years. A stretch of over a mile on a macadam road built in 1915, was practically ruined by trucks that were hauling material for the construction of a new pavement. This same traffic passed over a 15-year-old brick pavement and did no apparent damage.

A three-year-old penetration macadam pavement, 11 in. thick, built in three courses was damaged so badly by three months of truck traffic, that it had to be resurfaced. This same truck traffic passed over a concrete road that was four years old and did no apparent damage. The first cost of the concrete road was a little over a dollar a square yard more than the first cost of the macadam, but the first cost of the macadam plus the cost of repairs and resurfacing at the end of the third year, was greater than the cost of the concrete.

Nearly all of the macadam pavements are on clay soil. The average original cost per square yard for the macadam pavements was $1.95.

The Asphalt Type.—The first asphalt type of pavement on this system was completed in 1917, and from 1917 to 1925 eight improvements were made using this type.

Of the 208,361 sq. yd., 88 per cent is an asphaltic concrete 2 in. thick, and 12 per cent is a sheet asphalt 1½ in. thick, on a 2 in. binder.

The base under one section of the sheet asphalt type was an old brick pavement, and under the other section an old stone block pavement. The base under the asphaltic concrete is either concrete or macadam.

The thickness of the concrete base varies. Twenty-three per cent of the yardage is on 7 in. of concrete, 3 per cent on 6 in., and 37 per cent on a base that is 6 in. thick at the sides and 7 in. in the center. The concrete base is a 1:2½:5 mix. Reinforcing steel was used in 23 per cent of the yardage.

The macadam base is 10 in. thick, built in two 5 in. courses. Twenty-five per cent of the yardage is on this type of base.

Figure 7 is a graph showing the repair cost per square yard per year for all asphalt pavements.

Remarks on Asphalt Types.—Ninety per cent of the total repair cost was spent on one road which was a complete failure. The repair cost of this pavement was more than three times its first cost. The base under this pavement was 6 in. thick at the sides and 7 in. in the center. The subgrade was a

clay soil with low supporting value. The traffic on this road was heavy, a large part being truck traffic.

This county's experience with asphalt pavements has been so limited and the results so erratic that the cost data are of little value.

The average original cost per square yard for the asphalt pavements was $2.84.

Traffic.—The graph (Fig. 8) showing the motor vehicle registration in the county, when considered in the light of the fact that the county's population has tripled in the last 25 years, will give some idea of the service rendered by these pavements in the development of this rapidly growing community.

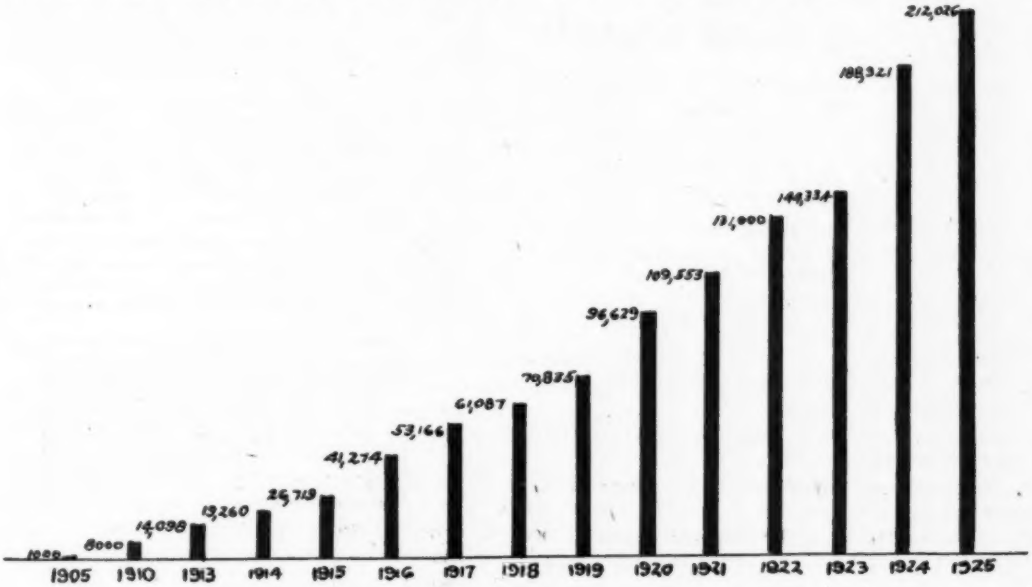


Fig. 8—Motor Vehicle Registration in Cuyahoga County

A recent traffic survey on the principal highways in Cuyahoga County, revealed a traffic on some of them amounting to 3,500 tons per day between the hours of 6 A. M. and 6 P. M. Figuring only 300 days in the year, this would total an annual tonnage of 1,050,000. It is reasonable to estimate that these pavements of early design and construction, built for light and slowly moving vehicles, have been carrying on an average of one million tons of modern traffic per year for at least the last five years.

The brick pavements being the type first laid in the county, naturally were laid on the principal traffic arteries and closest in to the city. Several of our heavy traffic routes are also paved with asphaltic types.

Conclusions.—In the rigid types of pavements, the two things responsible for the bulk of maintenance costs, were, unstable subgrades, inadequately drained, and weak, inferior bases. This fact is established by the excellent conditions of those sections of these old pavements that are found on sandy or gravelly soil.

In the non-rigid types, the principal causes for much of the repair necessary, are underdesign, cutting of the thickness to obtain a low first cost, and poor judgment in placing unsuitable types of pavement on roads where traffic and soil conditions demanded a better type. It is evident that it would have been more economical to have rebuilt or reconstructed those pavements that required excessive repair rather than to have kept them in service by patching them from time to time.

One of the surprising things brought out from this study of repair costs, is the excessive repairs made to pavements of some types built since 1915. Several have had considerably more than their first cost spent in repairs, and this too, before they had rendered ten years of service. In short, property owners needed a new pavement before the ten year bonds on the old one had been retired.

Mr. Simpson from his studies of repair costs on city pavements in Columbus, O., found a critical period in the life of heavy traffic pavements. This period was from nine to thirteen years. Cuyahoga County's experience seems to prove this critical period to be at about the same time.

However, we must realize both in the case of Columbus and Cuyahoga County, that we are considering a large yardage of pavements

that were designed and constructed either before the advent of heavy traffic as we know it today, or during the early phases of this heavy traffic. Whether this same critical period is to be found nine to thirteen years hence in pavements designed and constructed today, is another question.

In conclusion I think it behooves engineers who are designing pavements to put more of the "repair cost" in "first cost" instead of letting some road commissioner put it in later in "after cost."

Grading Road Gravel

Method of Ascertaining if Gravel Will Pack Into Hard, Uniform Surface Described in Paper Presented Before Canadian Good Roads Association

By E. SKARIN

President Crown Paving & Construction Co., Edmonton, Alta.

The object of this paper is to point out a simple and reliable method of telling beforehand whether or not a given gravel supply is likely to pack into a hard and uniform surface in a reasonable space of time.

First—It is important that the gravel be of a hard durable quality.

Secondly—It must not be too large in size, and

Thirdly—It must be properly graded.

We know that all inert substances, in order to be reasonably stable, must also possess a fair measure of density. The question then whether or not a given gravel deposit will pack into a hard and uniform road surface comes down to this one thing—density.

It then becomes necessary to sample the gravel with proper screens, and besides one must follow some method or formula in order to know when the maximum density is attained. If coarse gravel of say 2 in. is allowed, it is far more important that it is properly graded than if 1 in. were specified. It also follows that it is better for packing purposes to have an excess of fine material in the gravel than an excess of coarse material, provided, however, that the fine excess is not so fine as to approach a loam. Too much fine loam in the gravel will tend to pack easily, but it does not wear so well, and tends to become muddy in wet weather.

A small excess of the coarser ingredient within the size prescribed will take a couple of months longer to pack, but in the end will give a better road surface. It will last longer and give better service in wet weather.

Generally speaking, it is safe to say that if a fine gravel is used of about ¾ in. to 1 in., one need not worry much about density because the range is so small that there is bound to be present in most cases enough fine material to insure satisfactory packing. But, if coarse gravel is used, it becomes all important that it is well graded from coarse to fine in order to give reasonably good results.

Coming back to the formula for density there are several useful methods one can follow. In the state of Washington an almost straight line curve was used a few years ago. A still better formula is the Fuller's Density curve and is the formula used in Montana for both road gravel and concrete material. The

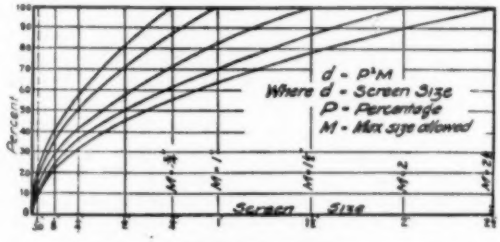


Table of Values

When M is	¾	1"	1½"	2"	2½"
And d = ¼	When P = 21%	P = 18%	P = 15%	P = 13%	P = 11%
" d ⅜	" P = 41%	P = 36%	P = 29%	P = 25%	P = 22%
" d ½	" P = 58%	P = 49%	P = 41%	P = 35%	P = 31%
" d ⅝	" P = 72%	P = 61%	P = 51%	P = 43%	P = 38%
" d ¾	" P = 100%	P = 87%	P = 71%	P = 61%	P = 55%
" d 1		P = 100%	P = 82%	P = 71%	P = 63%
" d 1½			P = 100%	P = 87%	P = 78%
" d 2				P = 100%	P = 90%
" d 2½					P = 100%

Fig. 1—Fuller's Density Curve

formula is also useful in any grading of aggregate such as asphaltic mixtures, and is the handiest method for checking density in all aggregates.

Figure 1 is a representation of the curve. It will be noticed that it is a parabolic curve. The formula is:

$$d = P^2M$$

Where d is the screen opening expressed in inches, P is the percentage passing a given size screen, and M is the maximum size stone allowed in a given sample of gravel under consideration.

The advantage of this curve is that it indicates clearly the proper proportion of the varying sizes that should be present in any aggregate where density is essential. The thing then to do with any gravel sample is to pass it through a set of screens and plot the resulting percentages alongside this curve. This will at once indicate whether there is close harmony between the two and if not it will clearly show what is lacking in the sample. A variation to either side of 15 per cent is usually permitted.

The 5th Annual Asphalt Paving Conference

Salvaging of Old Roads and Paving of Secondary and Tributary Highways Is Central Theme at Meeting

With a registered attendance of 708 engineers, public officials, asphalt producers, and paving contractors, the 5th annual Asphalt Paving Conference held at the Mayflower Hotel in Washington, D. C., Nov. 8-12 last, was the most largely attended and successful from the standpoint of profitable discussion of all that have been held. This year's meeting, as usual, was under the auspices of the Asphalt Association, and was made doubly important by the fact that the American Society for Municipal Improvements held its 32 annual meeting at the same time and place, so that there was ample opportunity for those attending each meeting to hear the discussions at the sessions of both organizations. That The Asphalt Paving Conference is growing rapidly in public interest and popularity was evidenced by the increased attendance this year and the exhaustive technical discussions that followed the reading of each paper presented. The attendance at the Washington meeting was nearly double that at the Detroit conference in 1925.

The central theme running through the sessions was that of salvaging old gravel and macadam roads and worn out streets with asphalt surfaces and the paving of the secondary roads of the nation, esepecially those highways that act as feeders for the railroads and lead to the markets of the world. Accordingly, the conference, near its close, went on record by resolution urging, not only the salvaging of the investment originally made in constructing and maintaining the older highways and streets as a measure of public economy, but the paving of the tributary highways so as to relieve the trunk lines of congestion, and afford the farmer a better means of marketing his produce.

Senator Moses Addresses Conference.—The matter of salvaging the old gravel and macadam highways, as an economic measure, was brought very forcibly to the attention of the conference by United States Senator George H. Moses of New Hampshire, president pro-tempore of the Senate and chairman of the Senate Committee on Post Offices and Post Roads, who addressed a joint meeting of the conference and the American Society for Municipal Improvements on Tuesday afternoon. The latter organization accepted the invitation of The Asphalt Paving Conference to sit jointly with it and hear the distinguished speaker. Senator Moses reviewed road building conditions in his own state and throughout the nation, discussed the heavy cost of modern motor highways and called attention to the fact that there is already a large mileage of highways now more or less obsolete for motor traffic, but in which there are abundant materials already compacted which he believed could be made of use as bases for modern pavements. The senator's remarks made such a profound impression on the officials and engineers in attendance that a resolution was adopted commending him for his position in this respect, calling attention to the fact that there are types of paving which are readily adaptable to just such a purpose as the senator had outlined, and urging a wider dissemination of knowledge upon the subject.

Other resolutions adopted urged the promulgation of more effective measures looking to the safety of motorists and pedestrians on the highways, recommending revision of bidding forms and the standardization of information required of bidders on highways contracts, commending the spirit of co-operation that exists between the engineers on the one hand and the contractors and others identified with the asphalt industry on the other, and commending the project of establishing an asphalt paving school under the auspices of The Asphalt Association. The resolutions were reported by a committee consisting of John B. Hittell, Chief Street Engineer, Board of Local Improvements, Chicago, Illinois, chairman; Col. R. Keith Compton, Director of Public Works, Richmond, Virginia; George C. Warren, Chairman of the Board, Warren Bros. Co., Boston, Mass; B. S. Russell, Jr., Cuyahoga Asphalt and Paving Co., Cleveland, O.; Hugh W. Skidmore, President, Chicago Paving Laboratory, and C. C. Lakin, Manager, Asphalt and Fuel Oil Department, Standard Oil Company of Indiana, both of Chicago, Ill., and J. S. Helm, General Manager of Asphalt Sales, Standard Oil Co., of New Jersey, New York City.

President's Address.—In his address formally opening the conference C. G. Shiefield of New York, President of The Asphalt Association, reviewed the remarkable progress that had been made by the asphalt paving industry in recent years, pointed to the importance of the petroleum industry as a factor both in the development of automotive industry and the successful working out of America's stupendous highway program. He said, the yardage of asphalt pavements laid annually on the streets and roads of America has increased from 55,000,000 sq. yd. in 1919, to 133,500,000 sq. yd. laid in 1925. Touching upon the question of conserving the investment in the old roads, President Sheffield declared that "it is nothing short of an economic crime to tear up these roads, representing, as they do, millions of dollars in value and having a compact se-

curity unattainable with reasonable cost by any substitute."

Col. J. Franklin Bell, engineer commissioner of the District of Columbia, in welcoming the convention to Washington, discussed the Capital City's sweeping program for civic improvements now under way and stressed the work that is being done in widening the streets, planting trees, establishing parks and providing better school facilities and a more adequate water supply. Among other things Col. Bell declared that there are in Washington approximately 800,000 sq. yd. of asphalt pavements that are more than 30 years old and are still giving good service.

Papers on Asphalt Macadam.—At the first session on Tuesday morning an interesting and profitable paper was presented by G. H. Henderson, State Highway Engineer of Rhode Island, in which state many trunk line highways are paved with asphalt macadam and are in excellent condition after being subjected to 10 to 15 years' gruelling traffic. The subject of Mr. Henderson's paper was "Causes of Success and Failure of Bituminous Macadam Pavements." Discussion of the paper was led by S. E. Fitch, county superintendent of highways, Jamestown, N. Y. Mr. Fitch's discussion was one of the best ever presented at a paving conference. Another interesting paper was presented at this session by R. M. Smith, Chief Engineer of Ontario Province, Canada, on the subject "Asphalt Macadam by the Mixing Method." In this paper Mr. Smith stressed two advantages which he said favored this type of paving, one of which was that during construction there is no interruption to traffic and the second was that the entire output of the rock crusher is used, thus materially reducing the cost. A practical paper on "Surface Treatment by the Hot Application Method" was presented by N. S. Anderson, Maintenance Engineer of the South Carolina State Highway Department, describing the experience of his state in surface treating its highways with asphaltic oils. The presentation of this paper was followed by a most valuable and interesting oral discussion in which several new points were introduced. After formally opening the session President Sheffield turned the gavel over to J. E. Pennybacker, General Manager of the Asphalt Association, who presided throughout the morning.

Contractors' Problems.—Senator Moses was the principal speaker at the afternoon session on Tuesday, being introduced by J. H. Cranford, Washington contractor and former president of the American Road Builders' Association, who presided. At the conclusion of the Senator's address the meeting resolved itself into a forum for an open discussion of two subjects of especial interest to contractors, namely, "Should Paving Contractors be Licensed?" and "Cost of Incompetent Inspection to Contractor and Owner." The feasibility of legislation for licensing contractors was questioned but numerous, valuable and practical suggestions pretaining to the rating of contractors and a reduction of the evil of irresponsible contract bidding were offered from both the contractors' and engineers' standpoint by George C. Warren, of Boston; B. S. Russell, Jr., of Cleveland; I. W. Patterson of Meriden, Conn., and H. C. McClure, city engineer of Flint, Mich.

Gen. R. C. Marshall, Jr., chief of construction in the United States Army during the World War, addressed the forum extemporaneously and the conference adopted a resolution commending the efforts that are being made by the Associated General Contractors towards devising a plan that will eliminate those evils of irresponsible contracting which are so deterimental to experienced, reputable contractors and so prejudicial to the public interest. Following the contractors forum the gathering listened to an interesting talk on Mexican oil production by W. J. Archer, representing the Mexican Petroleum Corporation, and saw a splendid motion picture, portraying the development of the petroleum fields in Mexico and presenting a striking view of a "gusher" coming in.

Papers on City Pavements.—At the session on Wednesday morning, Dr. Felix Kleeberg, chief chemist of the borough of Manhattan, City of New York, read a paper on "Construction of Granite Block Pavements with Asphalt Filler;" prepared by C. M. Pinckney, the chief engineer of the borough. W. E. Rosengarten, traffic engineer, The Asphalt Association, New York, presented the subject of "Asphalt Maintainance Without Recourse to Large Plants;" Linn White, Chief Engineer, South Park Commission, Chicago, Illinois, gave an illustrated talk on the development of South Park, and Jay Downer, Chief Engineer, Westchester County Park Commission, Bronxville, New York, gave an excellent extemporaneous address "Parks and Parkways of Westchester County." H. B. Smith, County Engineer of Burlington County, New Jersey, dealt with the subject of "Adaption of City Pavements to County Highways," and described the successful transformation of 85 miles of macadam into sheet asphalt pavements at remarkably low cost. Mr. Downer in his address described the steps that have been taken over a period of several years and the results obtained through the expenditure of some $30,000,000 for an extensive system of park and parkways in his county. Among other things he described the construction of the beautiful Bronx River Parkway which connects New York City through the Bear Mountain Parkway with the famous Storm King Highway in "The Highlands of the Hudson," which is conceded to be

the most impressive scenic highway east of the Rocky Mountains. Mr. White told of the stupendous work that has been accomplished in the reclamation of 1200 acres of lake bottom in the South Park section of Chicago. Lake Michigan at this point has been filled in and many miles of asphalt paved parkways had been constructed on the fill. Col. R. Keith Compton, director of public works, Richmond, Va., presided throughout the session.

Research Discussions.—The session on Wednesday afternoon was held in the auditorium of the building occupied by the National Academy of Sciences and the National Research Council, was under the auspices of the Association of Asphalt Paving Technologists, and was devoted entirely to research discussions. Francis P. Smith, an eminent consulting engineer of New York City, presided. The result of recent researches on asphalt paving mixtures constituted the text of most of the papers presented, and the subject of modification in cross-sectional design of asphalt pavements was also covered. The meeting was opened by an address from Dean A. N. Johnson, Chairman of the Advisory Committee on Highway Research of the National Research Council, who welcomed the attending engineers, chemists and contractors and explained to them the organization and foundation of the engineering division of the National Research Council. W. J. Emmons, highway research specialist, U. S. Bureau of Public Roads, described apparatus devised in the bureau's laboratory for studying the resistance to displacement of asphaltic concrete mixtures, also for the determination of voids in mineral aggregates used in paving mixtures. Mr. Emmons was followed by Gene Abson, director of the Chicago Paving Laboratory, who discussed the voidage theory of asphalt paving mixture design in practice with special reference to shear strength methods attested and developed the importance of the reduction of voids in paving mixtures in order to obtain a more durable result in practice.

A paper upon the "Correlation of Stability Tests with the Behavior of Pavements under Traffic" was presented by Prevost Hubbard, Chemical Engineer, and F. C. Field, Chemist, of The Asphalt Association. The stability test developed in the laboratory of The Asphalt Association measures the resistance of paving mixtures to the formation of ways and ruts under traffic, and much valuable data was presented establishing test values in connection with the behavior of asphalt pavements in the Borough of Manhattan, New York City, under the severe traffic conditions there encountered. "The Influence of Shape of Sand Grain on the Stability of Asphalt Paving Mixtures" was covered very thoroughly by Victor Nicholson, Engineering Chemist, Department of Public Works, Chicago, Ill., who brought out the important point that while sharp or angular sand produced the greatest stability in low filler mixtures, rounded sand could be used with equal satisfaction if the mixtures were properly proportioned and sufficient mineral filler added. Henry L. Howe, Jr., Director, Muncipal Testing Laboratory, Rochester, N. Y., described a gasoline deterioration test for asphalt paving mixtures which had been developed in his laboratory, for the purpose of ascertaining whether or not a paving mixture was resistant to disintegration from automobile oil and gas drippings and water and frost action. A. T. Goldbeck, director of engineering, National Crushed Stone Association, discussed the theory of "Cross Sectional Design of Asphalt Pavements" and offered a number of valuable suggestions relative to a modification of present practice intended to increase the low carrying capacity of such pavements in an economic manner. These papers brought forth much valuable discussion from engineering, contracting and material interests. Among those participating in the discussions being C. R. Stokes of the National Lime Association; Frank B. Bosch, of the Central Construction Corporation; A. R. Ebberts, Testing Engineer, Allegheny, Penn., Highway Department; A. W. Dow, Consulting Engineer, New York City; Hugh W. Skidmore, Consulting Engineer, Chicago; Col. J. W. Howard, Consulting Engineer, Newark, New Jersey; H. J. Hughes, Dean of Engineering, Harvard University, Boston, Mass and Chas. A. Mullen, director of Paving Department, the Milton Hersey Co., Ltd., Montreal, Canada.

Joint Session with A. S. M. I.—The final session on the morning of Thursday, November 11th, was a joint one with the American Society for Municipal Improvements with T. C. Hatton, of Milwaukee, Wis., president of the A. S. M. I., and George W. Craig of Chicago, Middlewestern branch manager for The Asphalt Association, presiding jointly. Features of this session were papers on "Construction Details Essential to Effective Hot Mix Pavements" by Francis P. Smith, New York; on "Black Base and its Place in Standard Specifications" by Hugh W. Skidmore, president of the Chicago Paving Laboratory, and a paper by Col. R. Keith Compton of Richmond, Virginia, entitled "Economics of Salvaging Old Pavements." Discussion of Mr. Smith's paper was led by W. W. Horner, Chief Engineer, City of St. Louis, and A. F. MacAllum, Commissioner of Works, Ottawa, Ontario, Canada.

R. H. Simpson, city engineer of Columbus, Ohio, led the discussion of Col. Compton's paper. The paper presented by Mr. Skidmore was unusually instructive, as the author had made extensive personal investigations of black base pavements in all parts of the country—partic-

ularly in the vicinities of Richmond, Virginia; Pittsburgh, Pa.; Patterson, Passaic and Trenton, New Jersey, and Chicago, Ill., and on state highways in Michigan and other states. Mr. Skidmore presented very substantial proof of the long life, low maintainance, economy of construction and standardization of methods to be found in black base pavements, and he urged that black base be regularly included as a standard type of construction for both county and city traffic. The discussion by A. K. Vickery, City Engineer of Denver, Colo., and H. F. Harris, County Engineer, Mercer County, New Jersey, emphasized the satisfactory results obtained with black base in Denver and in Mercer County. This type of construction, Mr. Vickery declared, is now the standard for Denver's great paving program, and in Trenton, N. J., Mr. Harris declared, experience has been very satisfactory with black base on highways carrying heavy industrial traffic. The paper by Mr. Smith outlined a number of important details which should not be overlooked in the construction of hot mix pavements, and his practical advice to road builders should result in substantial improvements in construction methods. In his paper outlining his experience with asphalt pavements, Col. Compton, besides discussing methods of salvaging old brick, garnite block, concrete and other pavements with asphalt, stressed the economics to be effected thereby. The cost of a new base, he asserted, could frequently be saved.

Entertainment Features.—Entertainment features for the convention included a bridge tea for ninety-six ladies in attendance at the Washington Club with Mrs. A. E. Phillips, of Washington, as hostess; a supper-dance-divertissement in the Italian Garden of the Mayflower Hotel, with entertainment by professional entertainers from the "No, No, Nanette" Company and other organizations, and an all-day golf tournament on Friday, November 12th, at the Congressional Country Club. The golf tournament was in charge of a committee consisting of A. E. Phillips and E. M. Callis of Washington, and T. E. Collins of Elizabeth, N. J. Prizes were won by C. R. Filbert of the Cincinnati Quarries Co., Cincinnati, Ohio, and Troy Carmichael, City engineer of Helena, Mont.

On Thursday afternoon the 700 delegates attending the conference were transported to the Pimlico Racetrack near Baltimore to witness the running of the "Walden Handicap" and six other events as guests of the Standard Oil Company of New Jersey, buses were provided for the trip and a box luncheon was served en route. The guests occupied sections of the grand stand especially reserved for them.

Second Annual Southwest Road Show and School

The second annual Southwest Road Show and School will be held in Wichita, Kansas, Feb. 22-23-24-25, 1927, under the auspices of the Wichita Thresher & Tractor Club, Inc. This show and school covers more than nine states and will be staged in Wichita's two million dollar Exposition Building, which covers almost a block, has more than three acres of space avaliable for exhibiting purpose, and was the scene of the very highly successful initial Road Show and School.

The Good Road School will be under the direct supervision of the Kansas State Highway Commission, and the Kansas State Agricultural College with the co-operation of the Southwest States, Federal and State Highway Engineers, and other organizations in the Southwest that are interested in the School and Good Roads.

More than 30,000 sq. ft. of floor space has been alloted to the Southwest States for Good Road School Exhibits, the United States bureau of public roads and other exhibits that will be brought to Wichita for the benefit of the Good Road School.

An elaborate program is being arranged for the Good Road School which will be announced later, to which everybody will be invited and admitted free. It will be arranged so that it will be exceptionally interesting and educational for state, county, township, municipal and road officials, contractors, material producers, and to anyone interested in the construction of good roads, maintenances, and construction work. The officers and directors of the organization promoting this show and school consist of:

A. D. George, President.

C. V. Newman, Vice-President.

F. G. Wieland, Secretary-Treasurer and General Manager.

A. A. Ward.

H. P. Peterson.

H. W. Cardwell.

W. J. Easton.

C. W. Ferree.

G. F. Ahlberg.

H. A. Smythe.

E. L. Kirkpatrick.

General headquarters have been established by the organization of 1927 Road Show and School at the Corner of William and Water Sts., Arcadia office of the Exposition Building, under the direct supervision of F. G. Wieland, Manager.

Construction of Bituminous Macadam Pavements

Practice in Rhode Island Described in Paper Presented Nov. 10 at 5th Annual Asphalt Paving Conference

By GEORGE H. HENDERSON
Chief Engineer, Rhode Island State Board of Public Roads

In Rhode Island, as well as in many other sections of New England, soil conditions vary within very limited areas. It is not uncommon to run out of gravel, into clay or other poor subsoil, and back into gravel within a few hundred feet along the line of construction. Were the subsoil of uniform texture, whether good or poor, the construction of the road insofar as foundations are concerned would be simplified.

Our frost depth varies between 2 and 5 ft. It is conceded by engineers that where frost action abounds extra care must be observed in providing proper drainage and foundations under road pavements. It is not the intention of this paper to expound on theories of drainage and foundation. Suffice to say that in New England where the soil conditions are so variable, if proper foundations and drainage are not provided in sections where poor subsoil exists the integrity of the pavement will be seriously threatened. It also is conceded that a layer of granular material directly beneath the pavement proper serves to break up capillarity and to lessen in a great measure the detrimental effect of frost action.

Method of Treating Subgrade.—It is our practice to replace poor subsoil with a uniform layer of gravel or stone foundation, the depth varying with the degree of tightness of the soil. The only rule that we have for determining the proper depth of foundation is the "rule of experience." We have seldom found a case of bad subsoil that a uniform layer of 12 in. of coarse, permeable gravel would not take care of, provided it is tapped out through the shoulders and properly drained.

Through ledge sections where water seepage may be expected we employ a stone fill of 9 to 12 in. with subdrains at least on one side of the road and frequent taps from the stone fill into the stone or gravel filled subdrain trench. Through particularly bad mucky soil we sometimes have laid a blanket course of sand or fine gravel, usually 4 to 6 in. in depth, over which we have constructed our standard stone fill, or stone foundation, the object of the blanket course being to hold the muck down and prevent its rising and filling the interstices of foundation above.

We believe that the almost total absence of heaving and breaking up of our macadams laid during the past 13 years is due to the method of treating the subgrade which has been in vogue during the above period.

Preparation of Subbase.—Considering only the intergrity of the pavement and its riding quality, several factors enter into successful construction. Of prime importance, of course, is the preparation of the subbase upon which the base course of crushed stone is to be placed. Whether the subgrade is of natural soil or a subgrade prepared by using gravel, coarse stone or any other granular material, it should be thoroughly compacted and made hard over the entire width of the pavement and preferably for at least 12 in. outside of the pavement. Any soft spots that are allowed to remain in the subbase will finally work injury to the riding qualities of the pavement.

Soft spots are not always caused by pockets of poor material constituting the subgrade. Often it is a case where the material in the soft pockets, while not bad in itself, is of such different nature of grading from the surrounding material constituting the subbase that it is soft in comparison. When contractors have been asked to eliminate soft spots in a gravel foundation they sometimes question the wisdom of making a substitution, their argument being that the material is granular and that it came out of the same gravel pit as the rest of the subgrade. They assert that the unevenness can be ironed out in the base course of stone. If it is allowed to remain and is not thoroughly ironed out in the base course of crushed stone, it is taken out in the top course of stone. Our experience teaches us that where these soft spots are allowed to remain in the subbase, even though any unevenness is taken out in either course of stone, it is only a question of time before a depression in the finished pavement will occur at the spot. The little inherent strength in the constructed macadam may bridge the spot for a while, even a year or two, but eventually it will let down.

Shoulders for Crushed Stone Course.—Another essential in good construction is the

placing of sufficient shoulder along the sidelines to hold the crushed stone courses. If care is not given to this detail, insufficient shoulder material may be placed to properly sustain the crushed stone at proper grade during the process of rolling. Where an insufficient amount of shoulder material is placed, the crushed stone during the rolling process pushes out to a greater or less extent, with the result that the outside edges of the finished pavement are uneven in contour or inclined to be scalloped. We have seen cases where the detrimental effect has extended into the pavement for two or more feet, injuring noticeably the riding quality of the pavement along its outside edges. In the event of future widening of the pavement it is necessary to cut back a considerable distance into the metal in order to obtain a standard cross section. In some cases where the widening of the pavement was not involved, traffic so avoided the outer two feet of the pavement because of its uneven riding quality that it was found necessary to rebuild the outer edge in the interests of safety to the traveling public, even though there was not a single break in the pavement.

The construction of the pavement proper calls for considerable care in the details. If the work is being done by a qualified contractor having an organization well versed in bituminous macadams construction, the battle is 90 per cent won. If an inferior contractor is doing the work, even under rigid inspection, it sometimes is difficult to secure a satisfactory job. We have seen bituminous macadams constructed successfully where the mineral aggregate used was not of the best in quality and during periods when construction conditions were not particularly favorable, and we have seen bituminous macadams poorly constructed where the best of materials were used and under most favorable conditions. The word "successful" is intended to cover both the lasting integrity of the pavement and the riding qualities of the same.

Aggregate for Bituminous Macadam.—In Rhode Island we have four classes of aggregate employed in the construction of the bituminous macadam: namely, crushed local wall or field stone, crushed local ledge, crushed local gravel, and trap rock which is imported from our neighboring state, Connecticut. The French coefficient of wear and toughness of our local stone vary within wide limits. Most of it we believe too soft for use in the wearing course of a bituminous macadam. Occasionally we find local ledges of exceptionally good quality. Where suitable local stone is available and the length of the work involved justifies the setting-up of a crushing plant, we employ local stone in the base course with success. In the wearing course, or penetration course except in isolated cases we employ trap rock.

With our local stone as crushed on the job we have difficulty in securing uniformity in size and quality. The lack of uniformity in crushed sizes of local stone we believe has little detrimental effect in the construction of the base course, but the same lack of uniformity in sizes we believe has a very definite effect if used in the penetration course. The breaking-down of the softer local stone under the roller plugs up the voids, which results in uneven distribution of the binder, causes fat spots, and is in general detrimental to the pavement. We use the harder stone in the penetration course because of its superior wearing quality and especially because of its uniformity in sizes. When laid this stone presents a more uniform distribution of voids for the penetration.

Where local stone is used in the base course most of the run of the crusher up to sizes passing a 3-in. ring are utilized. Where local stone is permitted in the top course the size is limited to stone passing a 3-in. ring and retained on a 1½-in. ring. In trap rock we use in the penetration course stone passing a 2½-in. ring and retained on a 1½-in. ring; for the filler, or key stone, sizes passing a 1-in. ring and retained on a ⅝-in.; and for the cover, clean ⅝ to ⅜-in. screenings. We have used a slightly smaller size in the larger stone with uniformly good results. The size of the stone specified can be varied somewhat, but it should run uniform in size and show an even distribution of voids when spread, which will permit of an even penetration of the binder to the full depth of the wearing surface. Our standard bituminous macadam calls for a 5½-in. base course and a 2½-in. wearing course. For binder we have used almost exclusively an oil asphalt of 85 to 100 penetration.

Method of Constructing Macadam.—With the above materials it is possible to construct a first-class bituminous macadam and all the varying degrees down to a poor bituminous macadam, depending for the most part on care used in the details of construction. As in the case of uniformly rigid subbase, we believe it essential that the first course of stone after the completion should be uniformly hard and true to coutour. The penetration course of stone should be uniform in depth to insure the best results. Men experienced in raking stone can secure this uniformity in depth and contour regardless of whether or not mechanical stone spreaders are used. If the stone spreaders are not expert, constant attention must be paid by the engineer in charge of this work or the riding qualities of the finished pavement may be poor.

It is our practice to fill the base course of crushed stone with sand or crusher dust during the rolling process. After the stone is first rolled, the sand is applied in light coats as the stone is rolled, more being added until the

bottom course no longer creeps or depresses appreciably under the roller. If heavy trucks are to be used on the base course for a considerable period before the top course goes on, a layer of sand or dust up to an inch in depth is sometimes spread over the bottom course to protect it. Before the top course of stone is spread this excess sand or dust is swept off of the bottom course to expose the stone in the bottom course and to permit a bond with the top stone.

Except in cases where extremely wide shoulders are available for traffic, before spreading the top stone we believe it absolutely essential that the ¾-in. and ½-in. stone, used as key stone and covers, respectively, be stacked in small piles along the shoulder of the road. It is poor practice to allow trucking through the top course of stone.

Asphaltic Binder.—In the application of the asphaltic binder, considerable finesse is involved. Fortunately, in Rhode Island the asphalt for practically all our jobs can be hauled over the road in pressure distributors from central heating plants belonging to the oil companies. Three-quarters of the area of the state is within 25 miles of these plants. Ordinarily we plan to get 1¾ gal. cold on the first application and ¾ gal. cold on the sealcoat. Needless to say, an even distribution of the asphalt is essential and also that the asphalt should penetrate the full depth of the stone. This can be obtained only by having the stone clean, by having evenly distributed open voids in the stone, by having the asphalt hot enough, and by having the pressure distributor in perfect condition mechanically. If the ashphalt is underheated, it does not get into the stone as it should.

The temperature of the binder can be regulated by thermometer testing better than by guesswork. Our specification calls for the binder to be heated to a temperature between 275 and 350° F. We believe as near 350° as possible is the best practice, especially in cold weather.

The nozzles of the pressure distributor should be tested to see that they are clear before the distributor is used.

Application of Asphaltic Binder.—In Rhode Island three types of pressure distributors are in general use. On one type pressure on the bars and nozzles is applied by steam generated by a separate boiler attached to the rear of the truck. With this equipment occasionally the pressure goes down before the full tank load is distributed. On another distributor an auxiliary clutch from the motor is used in obtaining pressure and the pressure obtained is in ratio to the speed of the truck. It is difficult to get high pressure and low speed at the same time. A third outfit has a separate power unit for generating air pressure, which unit has no connection whatsoever with the motor on the truck. With this outfit a uniform pressure can be obtained regardless of the speed of the truck.

Before the first penetration all foreign matter such as leaves, twigs, sticks, etc., which may have blown onto the top stone, should be removed.

The engineer in charge, knowing the volume of binder in the distributor and the width of spread, should figure the distance that should be covered in the distribution and place a stake at this point as an aid to the driver of the truck. No one but an experienced driver should be allowed on the distributor and he should average within 10 ft. of the mark on each distribution.

Where possible it is preferable to penetrate the left-hand side of the road first as the driver generally sits on the left side of the car and is better able to secure an even line of distribution. On our standard 18-ft. road it is our practice to spread 10 ft. on the first half of the road and 8 ft. on the second half. This system permits the spreading of the key stone and the rolling on the entire half of the road. The penetration must be carried a considerable distance before sealcoat is applied, owing of course to the fact that less asphalt is used in the sealcoat and a distributor load covers a greater distance. Where the first penetration was for a 10 ft. strip on the left-hand side of the road, a 10-ft. strip on the sealcoat is applied on the right-hand side of the road. In this manner of applications the sealcoat application and the penetration application are staggered.

Streaks in the penetration course of stone should be penetrated with a hand hose and not left for the sealcoat to cover up. When the streaks are not taken care of and are covered by the sealcoat, raveling often takes place after the sealcoat has been applied.

When the asphalt is not enough and there are skips, it is evident that the nozzles are plugged. Under this condition there is generally present a bluish smoke. If the bluish smoke is not present and there is streaking, it generally means that the asphalt is not hot enough and the distributor should be stopped and the asphalt brought to the proper temperature.

Too heavy an application of binder is to be avoided as it may be the direct cause of corrugations which develop after the pavement has been opened to traffic.

Rolling Requirements.—After the first application only enough key stone should be spread in order to permit rolling. A strip 8 to 12 in. wide should be left unfilled until the second half of the road is penetrated. This voids the spreading of excess key stone along the dividing lines of penetrations and prevents a ridge

developing along the center. After the initial rolling enough key stone is added to fill the voids in the top course of stone and the road is then rolled to its final cross-section. Hand pushbrooms or mechanical brooms or brushes of various types are used to spread the key stone evenly over the penetration course. All excess stone over and above that needed to fill the voids is cleaned off before the sealcoat is applied. The key stone is not a separate course of stone but only a filler and after it is applied the surface of the pavement should be mosaic in appearance. After the sealcoat application the pea stone is spread in sufficient quantity to completely cover the sealcoat.

In addition to skilful rolling required in the construction of a good bituminous macadam, it is essential that the pavement secure sufficient rolling to thoroughly compact the stone. We do not believe it possible to over-roll a bituminous macadam after the binder has been applied. It is our practice to require the rolling of the top course of stone to a firm set before the first application of the binder and to require the backrolling for several days after the pavement is completed. This practice demands more durable stone. In cold weather back-rolling is confined to the warmer part of the day—usually between ten o'clock in the morning and two o'clock in the afternoon.

It is our practice to open the road to travel as soon as the sealcoat has been covered. Occasionally when expediency demands it we have opened the road to travel after the first penetration was thoroughly rolled. We have experienced no bad results from this practice.

In the above we have sketched briefly our method of building bituminous macadams. We know that other methods vary in detail to a greater or less extent from our method. Doubtless there are many ways of building bituminous macadams: good, fair and indifferent. Probably it is the indifferent methods of building bituminous macadams that have been the direct cause of many failures.

In the construction of a reinforced cement concrete pavement, which has certain inherent strength, we are not prone to slight the details of construction. The question arises, should we slight the details of construction in a bituminous macadam which has little or no inherent strength? Doubtless if the same care were exercised in the use of materials and the construction operations of a bituminous macadam as is used in the construction of a concrete pavement, much better pavements would result and there would be fewer failures.

In conclusion, would say that a successful bituminous macadam generally follows where the essential details of construction are adhered to, while the slighting of these essential details of construction often spells failure. Probably the worst disease prevalent in road construction is that known as expediency, and few if any of us are immune from it. Expediency often calls for the use of materials not in accordance with specifications and sometimes calls for the slighting of essential details of construction.

Essentials for Securing a Successful Pavement.—To insure a successful bituminous macadam, begin at the bottom and provide proper foundations and drainage; construct a firm subbase; if there are weak spots in the subbase, remedy them before spreading the first course of stone; if there are uneven spots after the first course of stone is rolled, remedy the trouble before spreading the top course of stone; if spots in the top stone are tight due to an accumulation of small stone or the breaking-down of stone that should not be in the top course, remove them before the first penetration; if after the first penetration there are streaks, take care of them before allowing the sealcoat to be applied. In other words, constant care during the whole construction process should be taken and faults corrected as they occur.

Costs.—The average cost of our bituminous macadams proper, exclusive of drainage, foundations, engineering, etc., has been $17,750 per mile for an average width of 18 ft. The total average cost, including grading, foundation, etc., is approximately $32,000 per mile. Our average maintenance cost of bituminous macadam constructed since 1913 has been approximately $150 per mile per year.

We have one bituminous macadam constructed in 1913 which has yet to see its first sealcoat. Several of our bituminous macadams constructed in 1916 were sealcoated for the first time in 1923 after a period of 7 years. These bituminous macadams were for the most part constructed on our routes of heaviest travel. As far as we are able to judge, most of these pavements built since 1915 will serve traffic for many years to come.

Road Material Tests Under Actual Winter Temperatures

Materials used in federal aid highways in Kansas are being tested under actual weather conditions in the laboratory of the State Agricultural College at Manhattan, Kan. A special Frigidaire electrically refrigerated cooler capable of maintaining a temperature of 32° below zero F. has been installed. Stone, gravel and cement going into concrete for road work will be given various tests at even colder temperatures than will be experienced in actual use. The cooler has a capacity of 6 cu. ft. and is so constructed that materials can be under observation at all times.

Black Base As a Pavement Foundation

Extract from a Paper Presented Nov. 9 at Fifth Annual Asphalt Paving Conference, Washington, D. C.

By HUGH W. SKIDMORE
President, Chicago Paving Laboratory, Chicago, Ill.

It will be impossible to attempt to discuss in detail here the almost innumerable examples of "black base" throughout the country. But in order to indicate what is being done in a few localities, mention will be made of projects which were personally inspected during the course of the past summer.

Before proceeding to the consideration of pavements actually examined we must acknowledge the vast yardage of this type in our most western states. This yardage, which is far into the millions, is by no means dormant, but is increasing by added millions of

Michigan Trunk Highway M-14. Prime Coated Gravel Road Ready for Black Base

yards each year. In 1923 California alone had over 2,000,000 sq. yd. of "black base" pavement over 10 years old. The City of Denver has been building "black base" to the tune of about a half million square yards per year during the past few seasons. Likewise, in the south and some of the southwestern states, there is considerable yardage including numerous projects with lime-rock asphalt surfaces and also many examples of the same type of rock asphalt employed in the base.

Michigan State Highways.—The State Highway Department of Michigan during the past three construction seasons, has been engaged in an extensive program of "black base"—stone filled sheet asphalt paving over old graveled highways. During the season just passed, the state has operated two railroad plants on this work in addition to some similar construction by contract. In all, about 50 miles of such pavement will be laid on trunk highways during 1926, with a much larger program outlined for next year.

The pavement which has been laid is most excellent both as to design and execution. The old gravel roadways are bladed and roughly trued up and prime-coated with hot bitumen in advance of laying the "black base," drainage structures being first provided as on other paving projects. The thickness of black base varies in accord with the contour of the old roadbed, but has a minimum depth of about 2½ in. and a maximum of about 5 where the old gravel is quite thin and requires reinforcement. The base is laid 20 ft. in width and the top 18 ft. wide and 2½ in. thick. Bank-run gravel of quite uniform grading is used in the base course which shows the following typical composition:

	Per Cent
A. C.	5.6
Gravel	94.4

The gravel supply is controlled as to ratio of sand to coarse aggregate, and the appearance of newly laid sections of base, which were inspected, indicate that these proportions are maintained quite satisfactorily.

The top mixture is of the well known stone-

Laying Black Base on Michigan Trunk Highway M-14

filled sheet type of the following typical analysis:

	Per Cent
Bitumen	9.4
Filler passing 200-mesh	13.7
Sand passing 80-mesh	17.4
Sand passing 40-mesh	27.2
Sand passing 10-mesh	9.5

Stone passing 4-mesh	6.2
Stone passing 2-mesh	13.4
Stone passing ¾-mesh	3.2

Inspection of all the work laid during the past three seasons shows no defects of any kind.

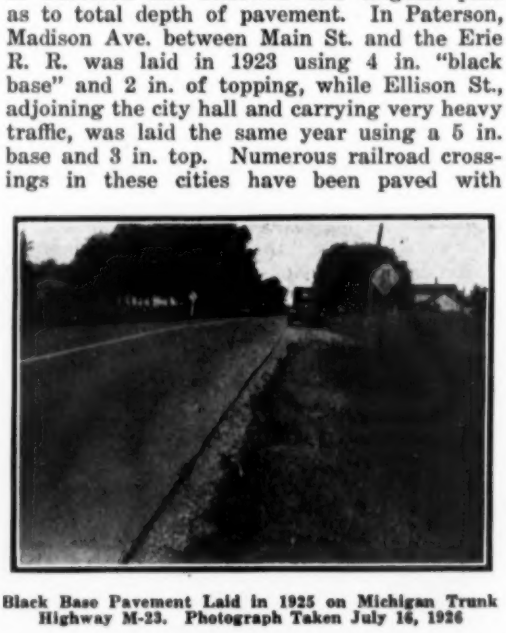
While we are in Michigan, we mention in passing that the City of Grand Rapids is laying from 50,000 to 100,000 sq. yd. of "black base" per year. These pavements employ a 4½ in. "black base" with 1½ in. top and they are costing less than similar wearing surfaces laid on rigid base.

Passaic and Paterson, New Jersey.—In these two cities are to be found numerous examples of "black base" pavement from 3

Black Base Under Construction on Michigan Trunk Highway M-14

to 5 years old. This type of foundation seems to have developed in Passaic some years ago, due to a desire to speed up construction which was originally intended to be standard 3 in. sheet asphalt on 6 in. portland cement concrete base. The contractor (Union Building & Construction Co.) suggested substituting 7½ in. "black base" and 1½ in. sheet top in order to permit the use of important thoroughfares several weeks sooner than would have been possible had portland cement concrete been used.

No doubt the 7½ in. base is somewhat excessive, at least in most cases in these cities, but one can readily understand how it came into use, since the contractor agreed to build for the same price, the same total thickness of an all-asphalt pavement as was provided for usual 6 in. portland cement concrete plus 1½ in. of binder and 1½ in. of sheet topping. All of the work in Passaic and some of that in Paterson has followed this original plan as to total depth of pavement. In Paterson, Madison Ave. between Main St. and the Erie R. R. was laid in 1923 using 4 in. "black base" and 2 in. of topping, while Ellison St., adjoining the city hall and carrying very heavy traffic, was laid the same year using a 5 in. base and 3 in. top. Numerous railroad crossings in these cities have been paved with



Black Base Pavement Laid in 1925 on Michigan Trunk Highway M-23. Photograph Taken July 16, 1926

"black base" and sheet top, with the utmost success. There has been no maintenance cost on any of the "black base" work.

The composition of the base mixture is:

	Per Cent
Bitumen	4.5
Sand	17.5
Stone, passing 1½ in.	78.0

This mixture was laid in two courses.

Mercer County (Trenton), New Jersey.—H. F. Harris, county engineer of Mercer County, told us in detail about his black base work at our Louisville meeting two years ago. In July of this year I had the pleasure of inspecting several miles of these pavements with Mr. Harris, and can vouch for the fact that they are giving service of the highest type. All of these pavements are on heavy traffic arteries either within the city of Trenton or immediately adjacent thereto.

The usual construction is 6 in. of base laid in two courses of regular binder composition, that is, employing comparatively small coarse aggregate, with regulation sheet asphalt top. Hamilton Ave. is an exception to this procedure as the base was laid 3 to 4 in. in depth over an old macadam roadway.

While we are discussing New Jersey work, mention is also made of quite a yardage of black base of the penetration type in Rutherford, all of which is giving an excellent account of itself.

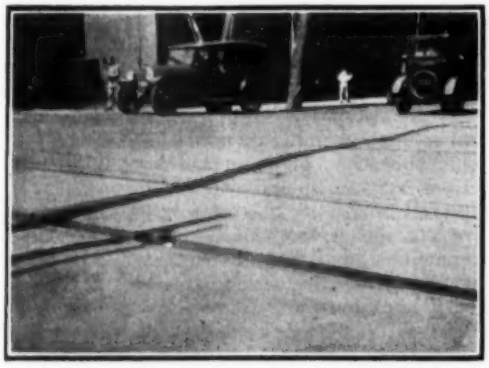
Richmond, Va.—Two years ago, the Richmond-Seven Pines Road was built under the direction of the Virginia State Highway De-

partment. This pavement consists of 4 in. of base and 1½ in. of sheet asphalt top. It would be difficult to imagine any pavement being built under any more adverse conditions. The soil is yellow clay which retains its moisture for extremely long periods. There is practically no side drainage away from the pavement and, to cap the climax, it rained almost constantly during the early part of the construction work. In fact, the soil became so saturated and unstable that the engineers ordered the work stopped for a period of six weeks during its progress. It is doubtful if a poorer location could have been chosen for any kind of construction especially without first correcting the subgrade troubles.

Despite this poor start, the work looks good. There have been a few areas along the edge which have depressed under traffic in the soft earth and these will require some maintenance. But on the whole, the job looks quite satisfactory considering the extremely poor conditions attending its construction.

The state highway officials realize the disadvantage the road is under and consider that it has made a remarkable showing.

Pittsburg, Pa.—You will recall the enthusiasm of J. D. Strain as he told us about



Typical Black Base—Sheet Asphalt Railroad Crossing Pavement at Passaic, N. J.

Pittsburg's black base at Detroit last fall. I can assure you that if you care to visit his work, some of which is 9 to 10 years old, you will agree that he has ample reason for being a strong advocate of this type of construction. As his guest, I inspected many miles of such pavement this past summer and I confess that I have never seen better. The yardage of such pavement in Pittsburg runs well into the hundreds of thousands. He tells me that none of it has cost the city a cent of maintenance and most of this work has been done on heavy traffic streets in the downtown district and on boulevards carrying dense traffic.

Much of the black base has been laid directly upon the native subgrade, while some such as Beachwood Blvd., was laid over old roadways and hence varies in depth from 4 to 7 in. In some cases such as Smithfield and Diamond St. (on earth subgrade) which carry extremely dense, heavy traffic, the base was laid 10 to 12 in. thick. Mr. Strain is justly proud of the fact that the entire block in front of the P. & L. E. station on Smithfield St. was completed, including excavation, base and top, during the working hours on a certain Sunday in 1921.

Rules for Foremen

Charles B. Ramsey, a member of the Kansas-Missouri Contractors' Association, has caused a group of instructions to foremen to be printed on the fly-leaf of each time-book used in his organization. These instructions, according to a members News Letter of A. G. C., read, in part, as follows:

"Do good work. It is cheapest. Take care of your material. Don't waste it. Protect it from weather. It is charged against your job. Take care of your tools. You may need them again. Protect the public. Never leave your job until every danger spot is barricaded and lighted. Make provisions for lights on Sundays and holidays. Protect the job you leave until it is made safe, or until you are sure someone else is protecting it. The public is careless. You be careful. Protect the company from damage suits.

"In keeping time be fair. Give the men what they have coming, no more. Give the company what it has coming. When you lay a man off, give him a time check, and note it in your book. Write the man's name in full. Mark on your book whether laborer, operator, truck, etc. Make a practice of writing instructions to truck drivers and others not under your immediate supervision.

"If any of your men are injured, however silghtly, see that they are cared for.

"Be sure to make a complete written report to the office the same day.

"On your daily report say what you did and where you did it. If you did nothing, say so, and why.

"Take special care to note all force account and private work, and see that your account and the inspector's agree. Straight-time men will report to the office every day that is not fit for their regular work. Failure to do so will be sufficient cause to withhold pay. Do good work."

$5,000,000 for New Jersey Parks.—Essex County, New Jersey, voted a $5,000,000 bond issue for purchase and maintenance of parks in the county.

Progress of Federal Aid Highways

An Address Presented Nov. 9 at Annual Meeting of American Association of State Highway Officials

By WM. M. JARDINE
Secretary of Agriculture

The decade just past has been marked by greater improvement of the roads of the United States and a larger increase in highway transportation than any other in the history of the country. As, from our present position, we look back upon the way we have come in these ten years the progress seems truly remarkable. Coincidentally this same period covers the span of the federal-aid road legislation and its administration under the Department of Agriculture.

As we entered the decade in 1916 there were less than two and a half million motor vehicles in the entire country, and less than 73,000 of these were registered as motor trucks. Today the trucks alone are more numerous than all motor vehicles at that time, and the total has doubled and twice redoubled in the ten-year period.

Progress in 10 Years.—In 1916 there were approximately 277,000 miles of surfaced roads in the entire country, only a small percentage of which were of the types now regarded as adequate for motor vehicle traffic. Today the mileage of surfaced roads is nearly if not quite twice as great as it was 10 years ago and more than 100,000 miles are improved with types of surface more satisfactory for service than waterbound macadam—a record of progress the more remarkable if it is remembered that during this same 10-year period it has been necessary to reconstruct a very large part of the mileage previously constructed.

Ten years ago there were only five states in which there was as much as a single improved transstate highway.

They were Massachusetts, Connecticut, New York, New Jersey, and Maryland—all eastern states and all of that small group in which the movement for better highways had been begun in the nineties. Today 25 states have improved highways continuous from border to border in at least one direction and 16 of these have completed such transstate arteries in two directions.

In 1916 there were 16 states in which there was no state highway department that could be recognized as competent to administer the construction of federal-aid roads, and they had no semblance of a plan for the development of a state system of highways. Even in those states in which the recently created state agency was endeavoring to introduce scientific and businesslike methods of highway improvement there were only a few in which a connected state highway system had yet been clearly conceived. Today there is in every state a definitely designated state highway system to the improvement of which the state governments are applying their resources.

These remarkable changes, occurring within the brief period of 10 years, distinguish the last decade as the most important in highway history; but the developments which are destined to have the most far-reaching influence upon the future are the establishment of the federal-aid policy and the elaborate and productive researches which have been carried out by the federal and state departments and other agencies.

Principles of Federal-Aid Policy.—Of the federal-aid policy it may be said that the 56,000 miles of road which have been improved under it are of less significance than the principles upon which the policy is founded, and which are thus given nation-wide importance.

It is a first principle of the federal-aid policy that all roads, by the nature of their traffic, are stamped as of local, state or interstate importance, and that this fact should be recognized in the administration and financing of their improvement. The law has, therefore, required the designation of a definite federal-aid highway system, including those roads of interstate importance in the improvement of which the national and state governments may properly combine their efforts.

From the first it has been required that the state should, itself, participate directly with the federal agency through a department of its government competent to assume the responsibility. In retrospect, this provision of the law appears as, perhaps, the most important federal contribution, responsible, as it doubtless was for the creation and strengthening of highway departments in many of the states. It is a notable fact that these organizations are among the most efficient of state institutions, and it is certain that to them must be ascribed the largest measure of credit for the remarkable improvement of our highways. There is gratification, also, in the

splendid cooperation which has at all times marked their relations with the Bureau of Public Roads.

Results of Research and Experimentation.—The importance of the contributions to engineering science which have resulted from the research and experimentation that has been so vigorously conducted since 1920 can scarcely be over-emphasized. The Bates road tests by the Illinois department, the Pittsburg, Calif., experiments and the various tests of the Bureau of Public Roads are known and studied throughout the world. By the general adoption of the thickened-edge section, a direct result of this research, the public has already benefited through increased service and lower costs, and the saving will go on as long as concrete roads are built.

As the result of a single study completed recently by the Bureau of Public Roads by which it has been demonstrated that brick of 2 and 2½ in. in thickness may be used to give the service for which 3 and 4-in. brick have previously been used, it is estimated that large annual savings are possible. A few thousand dollars and the earnest and devoted work of three or four of the bureau's engineers for less than a year have thus returned to the taxpayers of the states and municipalities, wherever brick pavements are built, many times the expenditure in potential cost reduction.

Similarly the bureau's studies of grading and concrete pavement operations have pointed the way to an improvement in the efficiency of such operations as a result of which it has been found possible in some cases with the same equipment to increase production by 50 to 100 per cent.

The results of these studies are immediately apparent in reduced costs and enhanced efficiency. In other cases, as in the studies of soils to determine their characteristics as highway subgrades and in the various investigations of the effect upon roadways of traffic and climatic influences, the object sought is complicated by so many variable factors that the studies must be long continued before definite results may be expected. But these researches, penetrating as they do to the very fundamentals of highway design, are likely in the end to be the most valuable of all, and it is not only possible but probable that future generations of road builders may regard them as in the same category as those fundamental observations by which the design of bridges has been converted from a rule-of-thumb process into an exact and dependable science.

Adequate Provisions for Increasing Service.—Turning from retrospection to the contemplation of the future, I am impressed with the necessity of making adequate provision for the increasing service that will be expected of the highways. If the number of motor vehicles has increased from two and a half to twenty million in 10 years, there is no reason to believe that the increase will be abruptly halted now, although we may expect some falling off in the rate. As traffic increases directly in proportion to the motor vehicles in service we must expect that the conditions for which we now build will be intensified in the future. The highway service we are now providing must be capable of expansion to meet the needs of the growing traffic as these mature.

Doubtless the concern of the immediate future is not for all of you the same. To some it is the completion of an initial improvement of a large mileage, previously unimproved, in the face of a demand for more adequate facilities on some of the highways already well developed. To those who face this situation the problem is to get the traffic through—to effect some degree of improvement over a whole highway system as rapidly as possible in order to give the greatest satisfaction to the greatest number of people.

Others among you—more fortunate, I believe—have systems of main roads already improved and largely surfaced, and the immediate concern is the selective betterment of sections of the system to relieve congestion, eliminate danger, and generally to adjust the existing improvement to the growing needs of a still increasing traffic.

The Policy of Stage Construction.—To all alike, however, the problem of the present is to serve as adequately as possible the present needs, keeping in mind at the same time the greater needs of the future, and making suitable provision for their accommodation when the time arrives. This is the policy of stage construction, a sound policy because it recognizes the utter impossibility of building once for all a system of highways which may be regarded as a finished product, but rather substitutes for that conception, the principle of progressive improvement.

The construction of earth roads on the lines and grades and with the drainage provisions that will be required by the pavement of the future is a recognized application of the stage-construction principle. But it has much wider applications than that. The acquisition of rights of way of ample width for the future so that, when the need arises, it will be possible without heavy expense or the injury of private property to effect the necessary improvements, is another highly important application. The same foresighted policy suggests the location of the improved highways in relation to railroads at crossings in such manner as to provide satisfactorily for separation of grades, and it applies also to provisions for the construction of future by-pass highways

around cities, and for the diversion of traffic from routes of growing congestion.

Anticipating the Needs of the Future.—To anticipate thus the needs of the future implies a knowledge of the probable traffic importance of the various roads which can only be obtained by a careful and detailed study of the present distribution and the factors inherent in the economic and physical characteristics of the state. Such studies have been made by the Bureau of Public Roads in cooperation with the highway departments of a number of the states, and the reports, recently published, are doubtless familiar, to many of you.

The highway department that has in its possession such information as these surveys supply can really plan for the future. It has substituted facts for opinions; it knows the present and probable future importance of its roads; it knows the density and also the weight of the traffic to which each road is now subjected and to which it is likely to be subjected in the near future.

It can, therefore, devise a reasonable program of construction extending into the future; it can budget its funds intelligently; it can determine the order in which the various highways should be improved and give a satisfactory answer to those who favor priority for other roads; and it has in its possession an adequate basis for the necessary decision as to the character of improvement required for each road.

This is sound and businesslike administration of highway improvements. It is the reverse of the casual and haphazard procedure which too often has subjected the business of highway improvement to political manipulation, and produced discontinuous, unbalanced, and uneconomical development instead of well articulated systems of improved highways.

In the federal-aid work we feel the need of such precise information daily and I look forward hopefully to a not far distant time when it will be available in all states.

Development Hampered by County Financing.—Not all the exact information it is possible to obtain, however, will suffice to provide an orderly and systematic improvement of the main roads in the states which still rely upon the financial assistance of the counties to carry out the state program. Certainly there has been experience enough to prove that complete connection of main arteries is practically impossible so long as there is dependence upon county financing. The reasons are perfectly obvious. All sections of the major state roads in the various counties are not invariably the roads in which the county interest is the greatest. By their very nature the roads of the state and federal-aid systems are the most heavily traveled highways. In many instances the traffic which demands their improvement is contributed in a smaller degree by counties through which they pass than by other counties or even other states. It is not unnatural that the authorities of such counties should be unwilling, and they often are financially unable, to assume a share in the cost of the improvement. So long as any state fails to provide state funds for such roads the development of the main state and interstate roads along strictly economic lines will be hampered.

Full operation of the provision of the federal highway act which aims to correct this condition has been twice deferred in the federal legislation to give the states concerned more time to correct their laws. There ought to be no further delay. I am sure that the members of this organization from the affected states will join with me in the hope that the necessary laws and constitutional amendments will be provided before the congress shall again have this legislation before it for further action.

It is manifestly unfair to the counties themselves to expect them to participate in the cost of improving the main lines of traffic. To do so places a burden upon them which they should not be expected to bear. The improvement and upkeep of the roads tributary to the main systems are of the highest importance to agriculture and the county and local funds must be preserved for this purpose. The traffic on the state roads is a wide-ranging traffic. The greater part of it originates in and is destined to the cities, and any system which causes the rural communities to contribute to the expense of improvement in greater proportion than the benefits they derive is unfair and ought to be remedied.

Greater Improvement Needed in Maintenance.—Looking to the future also there must be a still greater improvement in the maintenance of all roads and especially of the federal-aid roads, an obligation which the federal law places upon the state highway departments. While unquestionably there has been great improvement in this respect during the last decade, the failure to make proper provision for the repair of roads upon which large sums of public money have been invested is the sheerest of economic folly. Unless there is positive assurance that means will be available for the constant and continuous care of the roads after they are improved, I am convinced that it would be better not to improve them at all.

It has not often been necessary to enforce the provisions of the federal highway act in respect to non-performance of the necessary maintenance work on federal-aid projects. With few exceptions the obligation of the states has been carried out. There are a few —no more than can be counted upon the fingers of one hand—upon whom it has been

necessary to call repeatedly for essential work to save the federal-aid roads from deterioration. The department has been patient in dealing with such cases and our requests have always been met with a response but maintenance that is delayed until the deterioration has advanced to the point where it becomes necessary to direct attention to it, is not the right kind.

While the states in accepting the federal appropriations accepted also the obligation of keeping the roads in proper repair, the deeper obligation is that of rendering the best possible service to the public and of protecting public investment. Neither the public nor the legal obligation can be satisfied by a perfunctory highway maintenance policy. The department has endeavored to deal in a straightforward way with its duty to enforce the law in this respect. There has been no tendency to pick flaws of a minor character or to look with unsympathetic eyes upon the efforts of the states. It is not a pleasant duty to serve a formal notice required under the law upon any state, and it is still less pleasant to withdraw federal participation. The department believes, however, that its first duty is to insure proper maintenance of the roads constructed with federal funds, and this viewpoint I am sure will have the unanimous support of this association. There are a few states in which there have been too frequently reports of projects in an unsatisfactory state of maintenance, and may I take this opportunity to urge very seriously upon these states, which cannot themselves be satisfied with such conditions, their immediate correction. The department wishes to make clear its position that the duty to maintain roads already constructed is paramount.

The Interstate Highway System. — With each year's progress now it becomes easier to see the working out of one of the primary conceptions of the federal-aid road legislation as expressed in the requirement to expedite the completion of an adequate system of highways interstate in character. It was foreseen that the fulfillment of this purpose would come through a linking up of sections of main highways as they are developed state by state, and up to this time the programs within the states have in general been in harmony with the expected progress in the direction of through routes. In some cases the department has taken definite positions with reference to specific projects to provide missing links, usually in the way of bridges at state boundaries, but now with the major routes of the country so clearly defined by the action of the states through this association, the unimproved sections of these routes have been brought in strong relief. It is now possible to travel from Washington through St. Louis, Texarkana, and El Paso to San Diego, over a transcontinental route of which 97 per cent is improved, 93 per cent is surfaced and 4 per cent is graded and drained. Of the surfaced portion more than half is improved with bituminous macadam or higher cost types and the remainder is gravel. From Washington to St. Louis there is no unimproved section and nearly 96 per cent is surfaced with bituminous macadam or one of the higher type roadways. From St. Louis to Texarkana, 2 per cent of the distance is unimproved and 63 per cent is improved with a gravel surface, the rest with superior types. From Texarkana to El Paso there are unimproved sections equaling 4 per cent of the distance, gravel surfaces 50 per cent and bituminous macadam or superior type the rest of the way. From El Paso to San Diego, with the exception of 6 per cent of the distance, the road is surfaced, 60 per cent with gravel and the remainder with pavements and surfaces of higher types.

Progress on Transcontinental Routes.—This is the possible transcontinental route, totaling 3,133 miles, most nearly surfaced; 2,907 miles are surfaced and 131 miles are graded and drained, leaving only 95 miles without improvement. This route does not coincide with any one of the United States routes but it does indicate the splendid progress that has been made by the states it traverses in the completion of important transstate routes. Considered from the standpoint of improvement, the next ranking transcontinental route is that from Atlantic City to Astoria. Of its total length of 3,240 miles, 12 per cent is still unimproved, another 12 per cent is graded and drained, and the remaining 75 per cent is improved with some form of wearing surface. Of other east and west routes, that from Norfolk to Los Angeles is 68 per cent improved and that from Chicago to Los Angeles partly by the same line is 63 per cent improved. From Boston to Seattle, through the northern tier of states, the most direct through route is 73 per cent improved and 69 per cent surfaced.

These routes are taken to illustrate the working out of the principle, as defined in the federal highway legislation, of the completion of interstate routes. There may be critics who hold that the 10-year period covered by this legislation should have produced more transcontinental routes fully improved.

There are two answers: The actual operations of the federal highways legislation did not get under way until well into the year 1919, and the tremendous development of motor vehicular traffic, particularly around every center of population, large and small, local rather than transstate in character, has necessitated first attention to the immediate

service demanded. It is my feeling that the progress in the completion of transcontinental roads is gratifying, but I do not lose sight of the fact that the lack of transstate routes in the agricultural states of the Mississippi Valley is not in keeping with the development, east and west. In specific states this condition is brought about more largely by the feature referred to above, that is, the dependence upon county financing, than upon any lack of need of such roads or lack of response on the part of the state highway departments. Now that there has been plainly pointed out and defined the through routes which are of major national importance, there should be an energetic effort made to improve the missing links, not because they are transcontinental routes but rather because in general these unimproved sections lie on the most important state routes, and the failure to improve these imposes a handicap upon the people of each state in the satisfactory use of their own road systems. But the national use must not be lost sight of, nor the requirement of the national legislation that these interstate routes shall be expedited. The department has not attempted to dictate the routes which should be regarded as major state routes. Neither for that matter have the state highway departments. Through the careful work of the Joint Board of Interstate Highways, and the Executive Committee of the association, each state highway department has expressed in a definite way the routes which are of the greatest importance within the state. In other words, this system of interstate routes has been built from the local viewpoint upward and not from the transcontinental viewpoint downward.

Major State Routes to Be Completed by 1930.—But having now settled upon these routes, which in the last analysis the public itself has defined by their use, it becomes our duty, the federal and state highway departments working in cooperation, to expedite their completion. There are approximately 80,000 miles of highway included in these routes.

To complete them to a state of improvement satisfactory for present use is a matter of closing gaps. I am convinced that this, the initial improvement, can be completed by 1930 without difficulty, and as a definite objective I can think of no expenditure of effort which would bring with it a greater return of public satisfaction or any more intelligent method of keeping faith with both the federal and state governments which have entrusted to us the administration of these large funds.

Uniform Signing and Numbering.—The uniform signing and numbering of the United State highway routes in accordance with the reasonable plans now devised are essential in order to establish it in the public mind as an entity. They are needed also to develop the maximum degree of service and safety in their use by the ever increasing public traffic. From the federal point of view the early improvement of these routes is of large importance, and I ask your full support in an effort, when these designated routes shall have been ratified by this association, to complete the unimproved links at the earliest possible time and to bear with this department in a reasonable but insistent demand that the federal funds so far as possible be dedicated to this purpose with the full consent and belief on the part of the highway departments that the end is desirable and worthy.

Rubber Capped Brick Paving Blocks

An experimental section of rubber topped pavement has been laid on New Bridge St., London, E. C. We are indebted to The Surveyor for the following details: Upon a concrete foundation, similar to that prepared for wood block paving, a thin layer of sand is spread to form a bed for the blocks. These consist, in the normal size, of blocks of tough brick about 10⅜ in. by 8½ in. and 5 in. in depth, to the tops of which the wearing surface is keyed by dovetailing, the brick being suitably shaped for that purpose. While the actual surface is of a good quality rubber suitably treated or blended so as to give it the necessary toughness, this material does not depend merely upon the key as a fastening to secure it to the brick. A rigid connection is obtained by a layer of vulcanite to which the rubber composition and the brick adhere, forming a monolithic block. The vulcanite is so applied that it overlaps the sides of the brick block to a distance of an inch or more from the top edges, this overlapping layer being about ⅛ in. thick, and clinging to the sides of the block. The top edges are, therefore, not exposed, nor subjected to unbalanced pressure.

The blocks are laid with narrow spaces between them sufficient to allow of the formation of joints by pouring in molten bituminous preparation. The distance between the last row of blocks and the curb is reduced by placing half or one-third blocks, or both, any remaining space being filled with a suitable material such as stone chips with a bituminous binder.

The rubber surfaces of the blocks are lightly grooved in both directions in order to provide foothold, the pattern presented being such as would be obtained with somewhat thin bricks on edge, every second brick having a transverse groove, and all having slight arrises. The roadway thus provided is of a light creamy color.

The Trailer and Traffic Congestion

City Traffic Regulations in Relation to Trailers

By FRANK E. BARNARD

Sales Manager, The Eastern Trailmobile Sales Co., Inc., New York

The cities are getting deeper and deeper into the traffic problem. The constantly increasing volume of motor traffic has filled many streets to the curbstones.

It is apparent in the first place that since space on the highways has become so important, every type of vehicle that conserves space will be favored by traffic departments in practice if not by ordinance.

Signs of this tendency are increasingly evident. In New York City, which faces the most serious of urban traffic problems, there is a disposition to look with favor on the commercial trailer.

Types of Commercial Trailers.—There are two major types of commercial trailers—the semi-trailer and the four-wheel trailer. The latter couples behind any towing vehicle and doubles the pay-load of the motive power. It is the simplest of the trailer types, being little more than a highly perfected wagon—highly perfected in the sense that it has been built to trail without jerking or swerving, to track and to carry a load balanced on springs with the vehicle ahead of it. Generally the four-wheel trailer is used when hauls are long simply to double the payload—without at the same time increasing the running expenses more than 20 per cent.

The semi-trailer is provided with a fifth wheel or coupler that corresponds to a coupler on the tractor. Connected to the tractor it makes a six-wheel unit. The tractor backs into a waiting trailer that has been loaded or unloaded and connects automatically. When idle the front of the semi-trailer is supported by a pair of auxiliary wheels that raise or lower automatically with the coupling or uncoupling operation. When moving, its front end is supported by the tractor.

To the hauler, the semi-trailer brings two main advantages. It permits him to free his motive power—always the principal factor in automotive investment—during the time spent in loading and unloading, and it allows him to increase his loads.

It is the latter advantage which has attracted the favorable attention of municipal traffic departments and caused them to interpret regulations in favor of trailers wherever possible.

The ordinary tractor-semi-trailer combination can carry twice the load of a truck without breaking weight restrictions on the highways. The principal reason for this is that the load rests on six wheels instead of four. The crushing force of any load is distributed—and the greater proportion of the weight does not bear on the road through the drive wheels, which are the damaging agencies always, but on the free-rolling rear wheels of the trailers.

Obviously the trailer, although it carries a greater load, places less strain on pavements and road surfaces than the truck does. And obviously too, if it increases the capacity per motor unit, it decreases the number of trips required to make a given volume of delivery. In other words it makes fewer vehicles on the roads.

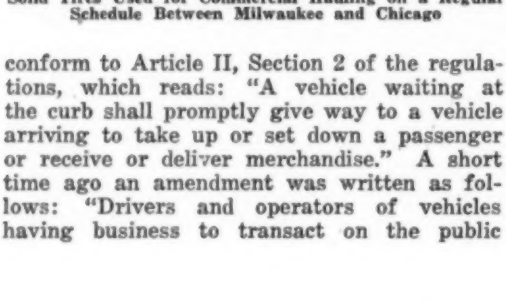
The Situation in New York City.—New York City does not attempt to regulate specifically the size and weight capacity of vehicles except in relation to bridges. But since the crossing of bridges is almost a necessary factor in hauling operations, the hauler is, to all interests and purposes, obliged to gauge his equipment by the ordinance governing bridge traffic. Under the present ordinance, a truck to operate without a special permit, may be 28 ft. long, including load, and a trailer must not be more than 18 ft., including load. A truck and trailer would therefore require 46 ft. of space to carry a load which would demand two trucks. The two trucks would need 56 ft. of space in body measurement alone—10 ft. more than the truck and trailer—and that would assume that they were practically touching each other in the traffic line. It would be more nearly just to say that every two tractors and two trailers would do the work of five trucks and thereby save the space of one truck on the highway.

A 3½-Ton 4-Wheel Trailer Used in Transportation of Dairy Products in Cincinnati

To understand the full import of the New York City situation it must first of all be understood that the ordinance which covers the use of trailers on bridges is not definite. The law would seem to say that when a vehicle exceeds 28 ft. in length it must have a special permit or be illegal. The law would also seem to say that the maximum gross weight for any vehicle is 30,000 lb. But the wording of the law permits an interpretation in favor of trailers—permits 46 ft. over-all length and a maximum weight of 42,000 lb. on the tractor-trailer combination. As a matter of fact this is the interpretation which the police department has chosen to enforce. In other words, those who meet the traffic problem on the ground and who deal with it not as a theoretical question but as a practical difficulty, are disposed to give encouragement to the use of the commercial trailer, for the reason that the trailer is helping to increase the capacity of urban traffic while actually reducing congestion.

In keeping the streams of traffic clear and the flow constant the Police Department of New York City faces a stupendous task. This task has been met not by arbitrary decisions and hot-house theories but by cool common sense, in which good humor is no slight factor. The success of New York's Police regulation of traffic may be due both to the common sense and the sense of humor with which it is enforced.

Parking of Trailers.—The attitude toward commercial trailers is both sane and advanced. The trailer is classed as a vehicle and is entitled to all the rights and privileges of vehicles. Take, for example, the problem of parking. Trailers, like all other vehicles must



An 8-Ton Interlocking Semi-Trailer with 36 in. by 10 in. Solid Tires Used for Commercial Hauling on a Regular Schedule Between Milwaukee and Chicago

conform to Article II, Section 2 of the regulations, which reads: "A vehicle waiting at the curb shall promptly give way to a vehicle arriving to take up or set down a passenger or receive or deliver merchandise." A short time ago an amendment was written as follows: "Drivers and operators of vehicles having business to transact on the public thoroughfares within the congested or business sections of the City of New York may leave their vehicles at the curb for a period not to exceed one hour, except that the provisions of Article II, Section 2, of the above mentioned Regulations must be complied with at all times by said drivers or operators."

One rule which the construction of trailers

A 4½-Ton Wide Frame Semi-Trailer with Built-in Platform Used by a Lumber Dealer in Buffalo

makes important to haulers is the amendment just cited. The trailer user wants to know whether he can leave his trailer standing at the curb without the tractor attached. If he can do this, he can take his motor, the tractor, to some other point where there is work to be done. The New York traffic regulations do allow such parking of unattached trailers —within the limits of common sense. In congested districts where there are hundreds of haulers, each must receive due consideration. Vehicles must, therefore, be in a position to move away as soon as their work is done—that is to say, as soon as they are loaded or unloaded. The fire hazards of a congested district also make it necessary for the truck user or the trailer user to be in position to give room for fire apparatus at a moment's notice.

There is no rule which says that a trailer may not be parked without its tractor. The rules which cover the case are general and applicable to all vehicles. They simply say that place must be given to incoming vehicles when the parked vehicle has been loaded or unloaded, and that in case of emergency—in which the officer stationed in that district has full power—the trailer must be able to move.

To sum up—provided he does not endanger life and property or obstruct the steady flow of business the hauler can drop his trailers freely and take full advantage of the special facilities which the trailer is intended to provide.

Tree Planting Along Massachusetts Highway.—During the last 21 years 51,331 trees have been planted on the borders of state highways in Massachusetts. A total of 1,671 trees was planted in 1925.

Pavement Design in Chicago

Report of Special Committee of Western Society of Engineers

Some time ago Miller McClintock, Director of Traffic Survey of the Chicago Association of Commerce asked for the opinion of engineers regarding certain features of pavement design which have a direct bearing on the traffic-carrying capacity of city streets. A special committee was appointed to draw up some suggestions along that line. The report represents the composite opinion of these members but is not the official opinion of the society. The committee consisted of L. S. Trainor, district engineer, Portland Cement Association; A. J. Schafmayer, division engineer, Board of Local Improvements, city of Chicago, and F. J. P. Seuel, engineer, Street Department, Commonwealth Edison Co. J. M. Mercer acted as secretary.

Items Considered.—This committee drew up an outline of 13 items which it would consider. The outline is as follows:

1. Minimum radius of curb return for different widths of streets.
2. Maximum crown of pavements.
3. Protecting sewer openings, drains, etc.
4. Maximum limits for height of curb.
5. Principles governing the construction of safety zones for street car loading.
6. Practice for safety islands on boulevards.
7. Proper width of traffic lanes.
8. Practice for marking traffic lanes in streets.
9. Markings for safety loading zones.
10. Concave (or center gutter) type of pavement.
11. Practice regarding sidewalk obstructions such as news stands, trash boxes, trolley poles, fire plugs, etc.
12. Practice regarding gutter openings for sidewalk crossings.
13. Use of battered curbs.

The committee reports on the above numbered sub-heads as follows:

1—Radius of Curb Returns.—The traffic density and character of traffic are not considered to be as direct a factor influencing the length of radius of the curb return as they are of the width of roadways and of street widths. Hence, in this case the main determining factors are the roadway width and the width of the sidewalk or of the sidewalk and planting space combined.

The need for more roadway space has led to the reduction of sidewalk space to the minimum and the same demand has led to the reduction of sidewalk facilities at intersections by increasing the radius of the curb corner. Practically all students of present traffic needs agree that all space possible should be allotted to the roadway traffic at street intersections. The ruling factor then becomes the space required for pedestrian traffic at intersections. A fair standard appears to be that the sidewalk space of the intersection measured at any angle should be at least equal to the width of the sidewalk. This condition would be met exactly by making the radius of the curb corner equal to the width of the walk. Since such a rule would result in a confusing variety of radius length, an effort has been made to establish a standard somewhat approximating these widths.

The following table shows the widths of roadway and sidewalks (including parkway) for various widths of streets:

66-ft. Street		80-ft. Street		100-ft. Street	
Rdy.	Sidewalk	Rdy.	Sidewalk	Rdy.	Sidewalk
30	18	38	21	50	25
38	14	40	20	60	20
40	13	50	15	70	15
48	9	56	12	74	13

Since it is not at all uncommon for streets of various widths to intersect, various combinations can occur. In attempting to meet these various widths, a standard radius of 15 ft. has been adopted in Chicago for normal conditions.

One of the principal factors to be considered in connection with the establishment of standards for radii of curb returns, is the turning axis of motor cars in use today. We are advised that the minimum turning radius of stock cars is about 19 ft. and the majority of the stock cars in use in America today have a turning radius of approximately 25 ft. There can be no question but that the desirable radius for curb returns is one which will permit the car in the lane adjacent to the curb (which is the proper position for the car which is about to make a right-hand turn) to remain in the lane immediately adjacent to the curb until it is in the lane adjacent to the curb of the connecting roadway. The desirable radius of curb returns, therefore, can be set at 25 ft. and from the viewpoint of the user of the roadway, this is a standard which should be adhered to wherever the physical conditions so permit.

It is obvious that such considerations cannot be given too much weight in a district such as the Loop District of Chicago where the density of pedestrian traffic is great. Here, the consideration of the safety and convenience of the users of the sidewalks must be the determining factor, and it is extremely doubtful if any rule can be put down. Even in these dis-

tricts, however, the radius of curb returns should be such as to permit free turning movements and the radius should be made to approach that mentioned in the previous paragraphs, that is 25 ft., or as nearly as may be permitted by the sidewalk conditions.

2—Maximum Crown of Pavements.—Most authorities agree that if drainage were not necessary the ideal pavement section from a traffic standpoint would be a level surface. Since drainage is necessary, it must be considered. The former crown formulas such as Warren's, Rosewater's, etc., and the earlier ones which gave rather high crowns are being discarded for empirical figures and flatter crowns. The reason for this is that with the more true surfaces now common on the modern pavement, the former steep crowns are not necessary to insure lateral drainage. There are certain factors, however, that tend to prevent crowns on pavements in a city like Chicago from being reduced to the degree that has been reached by some highway engineering organizations. One of these factors is the flat topography of Chicago. Another is the accumulation of snow, slush and ice in winter.

This topographical condition has resulted in the practice of securing longitudinal drainage by varying the depth of the gutters below the top of curb from the summits to the inlets. This results in a longitudinal undulation which is modified by varying the crown. When so modified the longitudinal undulation is not perceptible to any one driving within reasonable speed limits. The minimum crown, used at summits, varies from ¾ per cent to 1 per cent of the roadway width in feet. The maximum crown, used at inlets, is approximately 2 per cent of the roadway width in feet.

The winter conditions with snow and slush require a slightly steeper transverse slope, to keep the surface reasonably well drained, than is necessary in warm climates. For such conditions where systematic snow removal is not in effect, the above mentioned minimum slope is inadequate, but it gives a measure of drainage and in such cases a standard adopted must necessarily be somewhat of a compromise between conflicting demands. On the other hand, the above maximum crown is not ideal from the standpoint of avoiding skidding when wet or slippery. However, the fact that the surface of the pavement follows a curved arc instead of intersecting planes results in the two central quarters which carry the faster traffic having a much flatter crown than the two outer quarters which carry the slow traffic and parked vehicles.

3—Protecting Sewer Openings, Drains, Etc.—There seems to be little that can be established as general practice in this regard, but there are certain factors which seem to require emphasis. Inasmuch as it is necessary to depress the cover or grating over a catch basin inlet in order to permit the ready flow of water from the pavement, special precaution should be taken to insure construction sufficiently strong to prevent any further depression due to the impact of heavy vehicles passing over the inlet. Sewer openings should be of ample capacity to carry away ordinary accumulation of trash and permit the speedy removal of water and slush.

The minimum height of curbs may be zero at crosswalks and in such cases the movement of pedestrian traffic is facilitated. However, it may be objected that a careless driver may drive upon the walks. This is true but a reckless driver is as likely to drive over a 7-in. curb as a zero curb. The maximum height at cross walks should never exceed 7 in.

4—Height of Curb.—The minimum heights of the curb at intermediate summits between intersections should be 2 in. Less than this fails to give a clear line to the edge of the pavement and fails to retain the slush and water likely to be present at times.

The maximum height at inlets depends upon the distance between basins or inlets, the slope of the street and the height of the curb at the summit. An ideal maximum is 7 in. but details of design and consideration of economy in sewer appurtenances frequently indicate a curb height of 8 or 9 in. which should be permitted in particular cases.

5—Safety Zones for Street Car Loading.—Indiscriminate use of safety zones for street car loading should be avoided, but where it is found that the amount of traffic warrants the use of a safety zone, the elevated type is preferred. Safety zones are now being constructed in Chicago of concrete elevated 5 in. above the pavement and having the ends sloped. This type of safety zone has many advantages but wherever one is installed a mushroom light should be placed at least at its head to provide sufficient warning at night. Mushroom lights should be installed at each end of the safety zones which are not elevated and it may be desirable in congested sections to provide warning signs on removable standards. The elevated safety zone permanently settles the question of marking and provides easier entrance to street cars. There are now 140 safety zones in Chicago, most of which are of temporary type; that is, restrictions are removed at periods of light traffic. This is regarded as a temporary expedient and is under police regulation. The permanent elevated safety zone is thought to be more satisfactory. The greatest need for safety zones arises at the time of maximum passenger movement which coincides with the time of maximum vehicular movement but during times of light traffic, which invariably moves rapidly, there is continued need for safety zones. Removal of safety zone signs at

such times is dangerous because of the false sense of security on the part of waiting passengers who think they are protected because they are standing on a portion of the pavement which is designated by paint as a safety zone.

6—Safety Islands on Boulevards.—Safety islands at important intersections on boulevards are recommended and should be elevated and lighted. These zones should be as narrow as feasible so as not to reduce appreciably the traffic capacity of the boulevard.

7—Width of Traffic Lane.—An extended examination of the literature published on this subject discloses practically nothing on the width of traffic lanes for city streets. There seems to be an almost universal agreement on a width of 10 ft. for traffic lanes on country highways. It is thought that this should also be adopted for boulevards and streets devoted to fast-moving traffic. On heavy-traffic streets, it is thought that this could be reduced to 9 ft. for the reason that such traffic moves slowly. Further reduction is not thought advisable because of the presence of wide motor trucks and busses. Nine feet seems to be generally regarded as sufficient for parallel parking.

8—Marking Traffic Lanes in Streets.—In general it seems impracticable to mark more than the center line of streets. It might be desirable to mark additional lanes at such places as winding drives through parks and on boulevards, but in general the track over such streets seems to take care of itself quite satisfactorily.

9—Marking for Safety Loading Zones.—This is covered under section 5.

10—Concave or Center Gutter Streets.—Concave street pavement has been constructed in the new market district between Morgan St. and Racine Ave. Several other streets are now under contract to be improved with this type of pavement.

The pavements in the Market district have given satisfactory service so far. This district, however, has a very specialized type of traffic. Numerous arguments have been made for and against this pavement section. It appears quite certain that a saving in sewer costs can be effected and a saving in filling but if cutting is required the latter item will be increased.

From the standpoint of expediting traffic and ease and safety, this type of street has yet to demonstrate its desirability.

11—Sidewalk Obstructions.—Certain sidewalk obstructions may be removed while others are more or less stationary. Trolley poles and fire plugs are located according to more or less inflexible conditions. Trash boxes should never be permitted to be located near the corner. Mail boxes would be just as satisfactory if they were installed on the building fronts as soon as the people became accustomed to looking for them there. News stands are the worst offenders. They invariably seek the corners. They should not be permitted within 25 ft. of an intersection and should be located, preferably, in the middle of the block. City ordinances permit such stands to sell newspapers only. Practically all are violating this ordinance. The size of the news stand should be limited to that which is sufficient for the display of newspapers only.

12—Gutter Openings for Sidewalk Crossings.—The practice of building an extension of the sidewalks into the street and providing an under passage for the gutter at the curb line, has been discontinued in Chicago but many old streets with such cross walks exist. This has the effect of making travel in the outside of the street almost impossible.

13—Battered Curbs.—Battered curbs have been used on many pavements and have certain advantages. Two of the principal advantages claimed for such curbs are: (1) The ease of turning an automobile out, even when parked tight up against the curb, and (2) There is not the tendency for wheels to rub against this curb thus saving damage to sides of tires and rims and also to the curb itself.

On pavements where the topography lends itself to a curb design of uniform height this type of curb offers little difficulty. But with varying curb heights it presents several difficulties. If a uniform rate of batter is maintained and the line of connection with the gutter is held straight, the upper roadway face will meander in and out at the summits and inlets respectively. If the upper face is held to a true line, the lower edge meanders giving at some places a wider roadway and at others a narrower width. All these cause difficulties in setting concrete forms. If both top and bottom are held to a straight line and the rate of batter is varied a warped surface results with added difficulty in setting forms. In addition to these items, the appearance of poor alignment and the added opportunity its variableness would offer the many lawyers, who levy tribute on Chicago's improvements, to make still more vicious attacks are further reasons against its adoption in Chicago.

It is understood that the city of Chicago has abandoned the combined curb and gutter due to many failures of the gutter section. It proposes to use a straight curb 9 in. wide by 20 in. deep which will be installed after the pavement is built. The gutter will be built integral with the pavement and the curb will have a vertical face.

Wisconsin Counties Vote Bond Issues for Roads.—At the November election four Wisconsin counties authorized bond issues aggregating $5,656,000 for the construction of concrete roads.

Bituminous Treatment of Gravel Roads

Methods Employed in Province of Ontario, Canada, Described in Paper Presented at Annual Meeting of Canadian Good Roads Association

By R. M. SMITH

Chief Engineer, Provincial Department of Public Highways, Ontario

Light Road Oil.—This oil containing as it does practically no base has been applied with fair success on a considerable mileage of gravel road in Ontario. Care must be taken, first in the selection of the road to be treated; gravels containing a high per centage of clay or loam have a tendency to consolidate too rapidly, forming a mat or crust, which soon breaks causing numerous holes with a consequent rough and uneven surface. The gravel road should also be fairly well consolidated having a float of approximately 1 in. depth. The gravel with which the road is built requires to be a well proportioned material, not too high a percentage of sand and at the same time not too stony.

Bituminous Road Oil.—The bituminous road oil should have as little base as possible, also containing very little volatile material, the idea being to oil the float only, permitting it to be worked with the drags continuously, as on an untreated gravel or dirt road, no attempt being made to sweep or prepare the surface. Care must be exercised however in the applying of the oil not to use too great a quantity. One-fifth of a gallon to the square yard is generally considered sufficient. This amount will maintain the road practically dustless for two months which in Ontario fairly well covers the tourist season. The oiling of the surface of the gravel road lessens to a large extent the annual gravel application, thereby conserving materials, which will in all probability be required when a more permanent surface is applied at a later date. Bituminous road oil in Ontario costs approximately 15½ cts. per Imperial gallon applied, or roughly $375 per mile. All gravel roads on provincial highways are at least 20 ft. wide.

Surface Treatment.—In the treatment of gravel roads with heavy material, two methods are now accepted as being good practice. One known as "surface treatment" the other as "mixed method" treatment.

Treating gravel roads by "surface treatment" has received only little consideration in the Province of Ontario up to the present date, it has found considerable favor, however, in a number of states, more particularly the states of Maine, Wisconsin and Minnesota, in all of which a very considerable mileage has been treated. The method of applying surface treatment recommended is as follows:

Select the road to be given consideration, no mistake should be made here, only the highest type of gravel road should be treated. Surface treating of gravel roads does not mean the construction of a paved surface; too often officials are disappointed because the final results do not meet their expectations. Surface treatment is exactly what it says. The surface is effected to approximately 1 in. in depth, the gravel is more or less cemented together, the material conserved and the dust nuisance removed. The road surface to be treated should contain the best gravel obtainable free from clay or loam. It should be consolidated to a depth of at least 6 in., free of ruts or unevenness, true to crown and grade. It is false economy to treat any gravel road which is not subject to heavy traffic, which has no body or which contains poor materials.

The surface and other conditions being suitable, remove the float material if any quantity exists by use of light grader. When the float material is thin, however, this can be removed by a mechanical sweeper. The surface now being clean, it is ready for the first application. The quantity of bitumen to be applied at the first application will vary between one-sixth and one-quarter gallon. The latter amount to be applied providing the road can be closed to traffic during the spraying. Allow twenty-four hours to elapse before the second application, consisting also of approximately one-quarter gallon, is applied.

This second treatment is covered immediately with sharp sand, pea gravel or stone chips, just sufficient material being used to keep the bitumen from picking up; on a 20-ft. road from 70 to 80 cu. yd. to the mile. Where surface treatment as described above is being done under cool weather conditions, it is advisable to slightly heat the bitumen to secure greater penetration, also where traffic has to be carried during the progress of the work, it is advisable to complete half the road at a time.

With any class of road, maintenance is necessary. To provide suitable material for this work mix bituminous materials and gravel in proportion of 12½ gal. to 1 cu. yd. of gravel. Place this mixture in stock piles lo-

cated at convenient points along the road. They are then available for patrolmen when required.

After a road treated with bitumen has passed through the winter, a spring examination should be made to determine nature of future maintenance. On a high-type gravel road, it will sometimes be found that the surface is quite intact, that only patching is necessary. More frequently it will be found, however, that the surface due to poor materials, lack of drainage or some other condition, is so badly pitted it will require to be scarified and reshaped.

The scarifying should be done as early in the season as possible. Only light scarifying equipment is required in Ontario. Use is made of the power grader. The surface is scarified to a depth of possibly one inch, the broken crust being then worked with the grader until large lumps are thoroughly broken. The surface is then treated with approximately one-quarter of a gallon of bitumen and covered with pea gravel or chips as described in the original treatment. With the additional bituminous material added, it will be found that after the second year, it will be possible to miss a year without scarifying, otherwise each year will be identical with the treatment described.

Mixed Method Treatment.—This method of treating gravel roads has been developed with a view to using the gravel float and at the same time have a much greater depth of treated material. The object is to secure the greatest possible penetration into the hard road surface and in addition develop a mat from the float that will adhere and eventually become part of the hard surface.

In carrying out this treatment it is first most important and very necessary that the road have all the characteristics mentioned under "Surface Treatment." It is a more expensive method than ordinary surface treatment and, therefore, worthy of most careful study. The method of operation is as follows:

Prepare the road surface by liberal use of a light mechanical grader, the idea being to uniformly spread a float of gravel at least one inch in depth over the entire surface and at the same time remove any unevenness by cutting down the bumps and filling depressions. Where the required depth of float is not obtainable, additional gravel should be applied. This material should be of the best quality, free from loam or silt. The aggregate made up of sizes varying from coarse sand to one inch ring. After preparing the surface and before applying bitumen, the road must be allowed to dry, the less moisture the more successful the treatment. Bitumen is then applied over the entire surface at the rate of one-quarter gallon to the square yard. Some advocates of this method of treating gravel roads recommend that the bitumen be allowed to soak into the surface of the gravel for a period of one day. It is the practice in the Province of Ontario, however, to commence the mixing of the bitumen and gravel as soon as the first application has been completed. The treated gravel float is windrowed in the centre or partly to one side of centre of road by the use of the grader, the newly exposed surface is then treated with another one-quarter gallon of bitumen per square yard. The float material which has been pushed to one side is now moved onto newly treated area and the opposite side of road is treated in a like manner. The treated windrowed material is then redistributed over the entire surface of the road. The road is now turned over to the drag-man, who is expected to keep the road surface free of ruts and holes until such time as the surface is set up and thoroughly consolidated under traffic. This generally takes about one week.

Maintenance on this type of road surface is exactly the same as with surface treatment. The practice in Ontario is to provide patrolmen with a number of empty barrels, which are filled with bitumen at time of doing work, this material is mixed with gravel in proportion of 12 gal. of bitumen to 1 cu. yd. of gravel. The mix is then stockpiled ready for use when required. Holes and depressions are patched immediately they develop. This type of road as with surface treatment will require considerable study the following Spring. It has been found necessary in Ontario to scarify the road the next spring working up the surface until it is smooth and then applying another coat of bitumen approximately ¼ gal. to the square yard. The road should be in such shape after consolidation, following this treatment, that with constant maintenance it should not require to be scarified the second year.

The treatment of gravel roads with light oils is economical and can be justified where traffic is of a tourist nature and runs more than 500 vehicles per day. It is a known fact that traffic running one thousand vehicles per day will throw off the road as dust 300 cu. yd. of gravel per mile per season. The placing of gravel on our roads is costly, even the Province of Ontario with its apparent abundance of materials is beginning to experience a shortage of gravel in certain sections. Materials must be conserved; to conserve materials, they must not be allowed to blow away.

Where traffic is heavy, running over 800 vehicles per day more drastic action must be taken. Under this condition the heavy bituminous materials are recommended. The cost will run from $1,200 to $1,500 per mile

the first year, depending upon the type of treatment, but the results attained warrant the expenditure. The indications also tend to show that each consecutive year the cost will be decreased until the annual expenditure should equal about $800 per mile with practically no loss of material.

Cold Weather Concrete Paving

Precautions Suggested by Portland Cement Association for Continuing Construction and Avoiding Danger of Freezing Concrete

Concrete practically stops hardening when the temperature falls below 40° F. If the temperature remains about this point for several days after the slab is placed and then a drop of 10 to 15° comes, the concrete will freeze unless protected.

Concrete that is chilled to temperatures of 40° F. or less before it has hardened, is probably permanently injured. The injury may not be noticeable until the following spring or summer but should be rigidly guarded against.

If the following protective measures are used, the danger of frozen concrete is removed:

1. Dry up the mix as much as possible. The mix can be worked drier in cold than in hot weather.
2. Heat aggregates and water so that the temperature of the mixed concrete when placed on the subgrade is from 80 to 85° F. Do not heat the aggregates to the point where the crystalline particles spall. A heater in the mixer will help to keep concrete up to the desired temperature.
3. Place and finish each 30 to 50 ft, section as quickly as possible.
4. Place carefully stretched burlap on each section immediately after finishing and cover the burlap with a foot or more of straw. Cover the straw with tarpaulins which may be held down on the sides with dirt.

Never Place Concrete on a Frozen Sub-grade.—If the concrete is placed as dry as possible and is heated so that it is 80° F. when placed, the slab can be finished and covered before the temperature is greatly reduced. The straw and tarpaulin covering holds in the heat and will prevent freezing unless the temperature drops below 30° F. within 48 hours.

When the temperature is 32° F. or lower, the foregoing precautions must be strictly followed but instead of covering the slab with straw, frames should be made for each section and the frames covered with tarpaulins under which salamanders, oil heaters, steam radiators or live steam must be used. Live steam jets should not be directed towards the slab but at right angles to it. This will prevent excessive drying due to the hot steam and also prevent water dripping on the green surface. Heat should be applied as soon as each section is finished and should be maintained at not less than 60° for 72 hours.

Use of Admixtures.—In many cases too much reliance is being placed in the ability of admixtures to prevent frozen concrete. Admixtures containing sodium chloride (common salt) or magnesium chloride should not be used.

Within certain limitations* calcium chloride or calcium oxychloride may be used in portland cement mixtures to hasten hardening and to increase early strengths. The amount of the admixture required to produce the most beneficial effect seems to be dependent upon the chlorine content. Only small amounts of these admixtures may be used to advantage. The greatest acceleration is obtained with 2 to 4 per cent of calcium chloride or 7 to 10 per cent of calcium oxychloride by weight of the cement. With these percentages, tests covering a period of three years show no indications of reduced strength. If quanties of these materials greater than the above amounts are employed, the strength decreases.

When these compounds are used in cold weather work, they should not be used as a substitute for heating the materials and furnishing proper protection and heat to the finished structure, but only as an added precaution and as a means of shortening the curing period.

When calcium chloride is used, make a saturated solution by stirring into a barrel of water at 60° F. all of the flakes that will dissolve and add two pounds more. Keep an excess of the flakes in the barrel. Stir often. 4½ pints of this solution is the most that should be used per sack of cement. This is equivalent to 3 per cent of the cement by weight. Never add dry calcium chloride to the mix.

It should be remembered that calcium chloride only increases the strength normally to be expected by a certain percentage. In other words, if work is done in cold weather, it is only the cold weather strength that is being increased and not normal weather strength.

*There is evidence to show that calcium chloride and similar compounds do not react in the same manner with all brands of portland cement. Trial batches of the brand of cement and the brand of accelerator proposed to be used should be made up and rate of hardening and effect on resulting strength at the specified temperatures noted before proceeding with their use in important work.

Planning a Program of Highway Improvement

Considerations Resulting from Modern Traffic Conditions Discussed in November Public Roads

By DR. J. G. McKAY

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The last 15 years have seen the reemergence of highway transportation, one of the oldest methods for the movement of people and goods, from the position of comparative unimportance to which it had fallen during the period of greatest railroad development to a position of the first rank in the national scheme of transportation. Mass movement of people and commodities on the principal routes of the various state highway systems confronts us as a fact and not a theory.

Motor Vehicle Transportation.—The general field of motor-vehicle transportation can be divided into three major classes of service. First is the local distribution of commodities and local transportation of people. This service constitutes in tonnage the bulk of the motor-truck movement and is primarily the distribution of goods within cities and their suburban areas. In Connecticut 67.1 per cent; in Ohio 64.2 per cent; and in Pennsylvania 77.3 per cent of the net tonnage transported by motor truck is hauled less than 30 miles. Seventy per cent of the net tonnage hauled in Cook County by motor truck is a direct distribution of commodities to points of final use. In passenger transportation the principal function is also mass transportation within local areas.

The second principal class of motor-vehicle service supplements existing rail and water service by extension of freight and passenger service into areas not served by rail or water lines; substitutes motor-vehicle service for rail operation of unprofitable branch lines; and provides a combined service in conjunction with railroads or boat lines or both. The primary function of the motor vehicle in this joint movement is the movement of people or goods in the short haul.

The third class of motor-vehicle service is the so-called long-haul transportation. This type of service is not important as to quantity of movement nor would it appear to be economically sound. For motor trucks, at least, the volume of tonnage in the long-haul zone is comparatively small and decreasing in importance. In Connecticut 15.2 per cent; in Pennsylvania 6.9 per cent; and in Ohio 15.9 per cent of the net tonnage is hauled over 60 miles. Usually long-haul transportation is limited to movements in which speed of delivery or some special characteristic is the principal determining factor.

A relatively small percentage of motor trucks are engaged in the commercial transportation of freight. On the Maine highways 8.7 per cent; on the Pennsylvania highways 13.6 per cent; and on the Ohio highways 21 per cent of the loaded trucks are commercial, operating either for hire or on contract.

Analysis of motor truck transportation in the several states shows that the development of a large system of motor trucking over a considerable area beyond the short-haul is economically unsound. The movement out of cities is primarily a local process of distribution. The movement toward cities consists largely of goods produced in the area, principally food products. The volume of goods moving between two shipping points is unbalanced in the short-haul and progressively unequal with increase in distance. This fact negatives the development of long-haul motor truck transportation as a system of haulage.

The cost of providing motor-truck common-carrier service increases with increase in distance, owing primarily to the increasing terminal cost ratio to total net revenue, return movement of empty trucks, and partial loads at full rates or full loads at low rates.

The principal function of the motor vehicle as part of a correlated system of rail, water, and highway transportation, as indicated by present trends, seems to be its development in the short-haul zone with great potential possibilities of volume service in terminal areas of dense population.

The functional relationship of the motor vehicle and water transportation would appear to be the transfer of goods to and from docks and the mechanical organization of motor truck loading and unloading methods in the water shipping area to facilitate rapid loading and unloading of cargoes.

The principal service of the motor truck as a part of organized rail transportation is primarily in the rail freight transfer areas

and in the short-haul movement of rail package freight. Whatever we may think of present motor vehicle operating methods, if there is a real demand for this type of service it will continue to develop. The problem lies in the intelligent organization, improvement and control of this new type of transportation. Probably the next few years will see the organization of large motor vehicle operating companies functioning as a part of existing rail and water systems or as independent operating companies. Since the haulage of goods and people can be generally safeguarded by regulatory legislation, it would seem that present rail or water lines should qualify as the responsible financial and experienced agencies of mass transportation of people and goods in this rapidly developing field of motor vehicle transportation.

Meanwhile, no matter under whose guidance the organization of motor vehicle operation is developed, there remains the present problem of intelligently planning highway systems to serve this rapidly growing method of transportation.

Planning the Improvement of Highway Systems.—There is no fundamental difference in principle between the public business of developing systems of highways, and private enterprises engaged in producing commodities or in the performance of services. For example, light and power, gas and telephone utilities and other industries are all engaged in the production of their commodities for public use. The history of their modern development and expansion is largely a development based upon a careful analysis of the demand for their product by present and potential consumers in a given area. The soundness of their analysis of the need for new service and the expansion of their plant anticipating the demand for their product has been an influential factor in the progress or lack of progress of many communities.

The same basic economic and engineering principles of management that exert such a controlling influence in the field of private business should govern the public business of production in the highway field.

Applied to the public business of a state responsible for developing a connected system of improved highways to facilitate the transportation of people and commodities, the first basic principle of production management is that the various sections of a highway system selected for improvement and the type of improvement chosen for each section should be based upon present and expected future traffic demands, modified by the various physical and economic characteristics which affect the choice of specific construction types to be built on the various sections of a state highway system.

The second principle is the familiar one of the budget upon which all financially sound industries operate. Applied to the highway business it involves; (1) the determination of the amount of money required to complete the improvement; (2) the apportionment of the cost among those who benefit from the improvement of the highways, and provision through necessary legislation for raising the required highway funds. This management must insure the expenditure of the money in accordance with a predetermined plan of improvement in which each route or section of a route is to be improved to the degree required by the traffic and to no greater or less degree. The raising of revenue is the responsibility of the state legislature, and is always the final limiting factor in any program of public works. Provision by a legislature of more than the necessary revenue is apt to encourage waste; provision of sufficient funds, well managed by the highway department, results in a well-balanced system of highway improvements and the economic development of the state as a whole; provision of insufficient improvement funds defers the true improvement of a highway system forces the highway department to spread uneconomically its expenditures of State funds over the entire State system, usually results in the development of a highway system below the requirements of traffic, and, if continued over a period of years, increases the total ultimate of highway transportation.

The establishment of scientific plans for highway development, which will result in the maximum of highway improvement and highway transportation service, with available revenue, labor, equipment, and building materials, requires a careful analysis of highway traffic, the trend of its development and its distribution over the highway system. The necessity of such an analysis is now recognized by highway executives, but their efforts have been handicapped by lack of precise knowledge of the character and amount of present and expected future traffic using the various sections of the system.

The plan of State highway improvement may materially alter the economic and social development of a people as a whole or any section thereof. The location and improvement or lack of improvement of a given route is of vital importance not only to the traffic of the immediate locality but also to the traffic of larger areas. Therefore, the development of a system of highways should not be judged as miles and types of highways constructed each year but considered in terms of the movement of people and goods. The planning and construction of a connected system of highways deal in fact with the destiny of localities and States, their agriculture, their industries, the

growth of suburban areas adjacent to centers of population, and the social activities of a people. This is a tremendous social responsibility and not merely a problem of physics concerning mixtures of cement, water, brick, steel, bitumens, stone aggregate, gravel, equipment, and labor into what we now term the modern road.

Whether to Improve and How Much the First Questions.—The major problem is not one of the particular type of materials to use, but rather whether to build or not, and how much highway service should be furnished in a given area. Upon the proper solution of these problems depend the well-being and progress of a people. Considering the improvement of highways from this point of view there can be no question concerning the necessity of developing sound plans for highway improvement over a period of years in the several States, and of providing the necessary money to carry out economically the proposed plan of improvement.

The principal classes of highway improvements are: (1) New construction, (2) stage construction, (3) reconstruction, (4) building of bridges and culverts, (5) highway and railroad grade separations, (6) widening of present highways, and (7) methods of guiding and safeguarding traffic.

Each of these classes of improvement, although more or less distinct as a class, is part of a general scheme of betterment, and especially within congested population and traffic areas the highway engineer faces the urgent need of solving all these complicated problems of highway improvement. The development of the plan as a whole, including each of the several classes of improvement, should be based largely upon present and expected future traffic and "lay-out" and condition of the existing highway system in any given area.

The first step in planning a program of highway improvement is the measurement of the present, and the prediction of the future volume and character of traffic on the State primary, secondary and tertiary systems. The principal traffic factors involved in judging the relative traffic importance of the three systems, or sections of each system, are the average daily and maximum total traffic, and the average daily and maximum truck traffic using each section. The average daily number of loaded light (one-half to 2½-ton), medium (3 to 4-ton) and heavy (5 to 7½-ton) vehicles is an important factor in the determination of the plan of improvement as well as in the selection of the types to be constructed.

The second step is the determination of the relationship between population and demands highway service and the consideration of present density of population and population trends as an aid in the development of a plan of improvement which will most efficiently serve the traffic needs of this population.

The next step is the classification of the various highways or sections of highways as major traffic routes (class A), secondary traffic routes (class B), and minor traffic routes (class C). A class A highway is defined as one that requires one of the so-called rigid types of improvement, concrete, brick, bituminous concrete, or their equivalent. A class B highway is defined as one that requires a so-called flexible type of improvement, such as standard bituminous penetration macadam or its equivalent. A class C highway is defined as one that requires other lesser types of improvement.

The principal traffic factors involved in such a classification are:

(a) Average daily and maximum total traffic and truck traffic.

(b) Forecast of average daily total traffic and truck traffic for periods of 5 and 10 years.

(c) Average daily and expected future number of loaded light, medium, and heavy trucks for each route or section of route.

(d) The ratio of the total number loaded trucks to the total traffic in order to separate for special consideration routes or sections of routes on which motor trucks are an abnormally large or small proportion of total traffic.

(e) The number and frequency of critical heavy loads.

(f) Average maximum traffic as one measure of the width of the improvement, the necessity for improvement of additional parallel routes and the "by-passing" of congested centers of local traffic.

(g) Analysis of highway maintenance and capital costs and vehicle operating costs as an important factor in determining the traffic limits for the various types of improvement.

The fourth step is the measurement of motor-vehicle mileage on the primary, secondary, and tertiary highway systems, and the estimate of the earning capacity of these three systems to determine the relative vehicle-use value of each as a guide in developing the plan of improvement and the budgeting of construction and maintenance funds.

Finally, we must have a thorough analysis of the present system and the physical condition of the existing improvements on it, since the plan of betterment must, in general, incorporate the existing State highway system as the basis of the improvement plan.

Special Consideration Necessary for Highway System Adjacent to Cities.—A State plan of highway improvement can be separated into two distinct planning phases.

The first is the general State plan, consist-

ing of a connected system of primary, secondary, and tertiary routes serving each section of the State. It should be recognized that just as there is a considerable variation in the present and expected future volume of traffic on the highway systems of the different States, so there is within each State also considerable variation in the present and expected future traffic on the various sections of the primary and secondary system.

The second phase of the State plan is the special consideration necessary in areas adjacent to centers of population. The improvement plan of the State and the plan of improvement of the larger cities within it should be worked out cooperatively.

This cooperative planning is essential to the proper location and entry of State routes into congested traffic areas, to avoid dumping traffic from one or more than one State route into an already congested area, to provide for adequate connections and improvements of the city streets that join State routes at city limits, to make provision for "by-passing" congested traffic areas, to eliminate obstructions to the easy movement of traffic, and finally to provide belt, arterial, and secondary local traffic routes to facilitate the rapid, safe, and unobstructed flow of traffic in congested traffic areas.

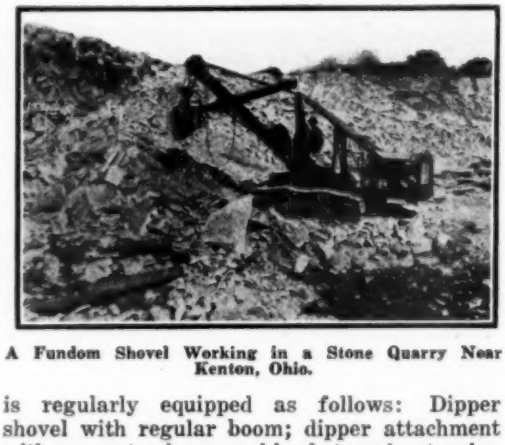
In the final analysis the worth of a transportation survey and the resulting plan of highway improvement is measured by the actual highway construction, reconstruction and widening program which is carried into effect over a period of years.

The State highway engineer, as the executive director of the public business of providing highways, is responsible (1) for the analysis of the traffic demand for his product on the various sections of the State system; (2) for a financial analysis of the yearly cost, the revenues required, the funds available, and for the establishment of a budget for the period of the improvement program; and (3) for the business and engineering management of the improvement program.

The major limiting factor is the financial program set up by the legislative organization responsible for raising the revenue to give reality to any plan of highway improvement; and therefore a large part of the responsibility for the character and condition of a State system of highways rests upon the department of the State government responsible for the raising of highway funds and not upon the department charged with the duty of constructing the highways.

New Small Power Shovel

A new shovel in which the Fordson is used as a power unit has been placed on the market by the Fundom Hoist & Shovel Co., Lima, Ohio. The shovel has a straight line drive shaft from shovel mechanism to the draw bar tail screw of tractor which permits using the standard Fordson transmission and gives the operator a choice of three speeds for all operations. The general dimensions are as follows: Length overall without boom, 14 ft.; width overall, 6 ft., 8 in.; height from ground to top of mast, 9 ft., 3 in. The weight complete is 7 tons. The working dimensions are: with boom at 45°, 16 ft. 6 in. radius dump; with boom at 60°, 15 ft. radius dump; clearance under open dipper lid, 12 ft. 6 in. The shovel



A Fundom Shovel Working in a Stone Quarry Near Kenton, Ohio.

is regularly equipped as follows: Dipper shovel with regular boom; dipper attachment with excavator boom and bucket, and extension boom with drag line bucket.

The regular boom is 12 ft. long, constructed of 8 in. channel reinforced with plates and ties. The mast consists of two 6 in. channel members fastened at the lower end on yoke casting; the upper end supports the mast head casting. The crowding mechanism is operated by double pad thermoid lined clutch, driving link chain to support shaft, which is provided with two steel, machine cut pinions meshing with steel machine cut racks on dipper handle. The dipper is of heavy steel plate construction and is equipped with manganese steel rooters. The capacity is ⅜ yd. level full. The dipper stick is constructed of two 6 in. channels. 9 ft. long, provided with stiffeners. The boom extension, which is used for crane with hook, clamshell, dragline or backfilller, or general hoisting purposes, is of angle construction with straps; it is 11 ft. long, and gives a total length of boom of 22 ft.

All digging operations are controlled by three hand levers and two foot pedals, all conveniently located. The machine has a traveling speed of 3 miles per hour.

Studies for Pavement Reconstruction

How They Are Made by California Highway Department Described in California Highways

By C. S. POPE
Construction Engineer, State Highway Commission of California.

The studies necessary for a proper investigation of pavements which it is proposed to reconstruct have been given attention by the construction department and some of the features entering into the problem are presented herewith:

Grade and Alignment Survey.—It is usually desirable, though not always necessary, that a grade and alignment survey with the necessary cross sections should be made. If grade and alignment surveys show that an extensive destruction of old pavement will result or if the original line will be deviated from seriously the economic comparison of pavement types may be extensively modified; as may also the condition survey hereinafter mentioned.

Surveys should give grades and cross sections of the old pavement with sufficient accuracy to determine the amount of surface material in tons or cubic yards which will be required.

Curves which do not conform to present standards for either horizontal or vertical curvature should be studied and reconstructed where necessary.

Superelevation needs to be provided for in most cases as a considerable amount of former work is lacking in proper superelevation.

Grade in excess of 3 or 4 per cent of excessive curvature is usually considered a condition adverse to asphaltic types of surfacing, though recent developments in pavements of this type should make a change in sentiment in this regard.

Condition Survey.—Before deciding upon a pavement type for reconstruction over old paving a condition survey of the old pavement should be made.

In the case of an old stone or macadam or bituminous macadam road, if the same is on the proper grade, an accurate determination of the thickness of road metal available should be made by digging through the road metal at intervals of not over two hundred feet.

Cuts should be made through the crown and at each quarter point and the thickness recorded.

If old concrete is to be resurfaced it should be examined and classified at suitable intervals in accordance with the Bureau of Public Roads classifications which are as follows:

Class A—Normal number of transverse cracks but no longitudinal cracks.

Class B—More than normal number of transverse cracks and some corner breaks.

Class C—Similar to A and B but with longitudinal crack and a considerable number of corner breaks.

Class D—Transverse and longitudinal cracks so numerous as to break pavement into slabs less in area than Class C but not less than 50 sq. ft.

Class E—Cracks so numerous as to break pavement into slabs less than 50 sq. ft. in area but no general disintegration.

Class F—Badly broken and with disintegrated paving.

If the old concrete has been surfaced, the surface should be removed at intervals for a width of 1 ft. across the entire width of the pavement in order to properly examine the base.

It is generally assumed that a concrete pavement in Class C condition or better, may be successfully surfaced with asphaltic concrete from 1½ to 2½ in. minimum thickness.

Paving in Class D or Class E condition may sometimes be saved with asphalt concrete surfacing from 2½ to 4 in. in thickness, although additional concrete base construction is considered better practice, except on the best foundation soils.

Paving in Class F condition usually requires complete reconstruction, though sometimes it may be saved by use of second story concrete.

Economic Traffic Study.—An economic study of pavement types is impossible without a proper traffic census, a knowledge of the first cost of various types of pavement and accurate information as to the cost of maintenance of each type. Formerly this information was not available, but under our present methods of recording information, the various factors required for a proper solution of this problem will be available with increasing accuracy each year.

If we are able to establish accurately certain factors the economic trend of the problem of comparison of types is quite simple, and may be reduced to mathematical solution.

Soil Survey.—It is now common practice to make a soil survey even for reconstruction work.

Both alkali and adobe soils have been found adverse to concrete pavements and require treatment before such pavements are laid. Sandy soil is particularly favorably to concrete pavements.

Asphaltic concrete and macadam are not affected by alkali, but require special base construction to be entirely satisfactory on adobe soils.

Among other matters which should be given consideration, in addition to the above mentioned matters of major importance, are the following:

Make a survey of road building materials available and establish availability of material and plant suitable for different types of construction.

Report prevailing weather conditions and usual amount of wet weather which might be unfavorable to any particular type of paving.

Consider and compare following constructions:

(a) Flush sholders of concrete.

(b) Asphalt macadam surface and shoulder.

(c) Asphalt concrete surface and shoulder.

(d) b and c with portland cement concrete shoulders.

(e) Sheet asphalt in combination d.

(f) Second story concrete.

Compare the consistency of recommended construction with that used in other parts of the state under similar conditions.

From the above brief outline it should be apparent that sound practice dictates that conclusions and recommendations for the type of construction to be used should be reported without regard to personal preference and opinion but in accordance with an economic and engineering analysis based on destructive traffic to be carried by the particular road under investigation.

Street Cleaning and Sprinkling at St. Paul

The city of St. Paul, Minn., has 391.2 miles of streets graded only, 24 miles of macadam roads, 195.6 miles of paved streets and 11.3 miles of paved alleys. We are indebted to the 1925 report of John H. McDonald, Commissioner of Public Works, for the following detail regarding the sanitary service for the paved area.

The paved areas—streets, bridges and alleys—amount to 4,487,000 sq. yd. Of this, 58 miles or an area of 1,365,000 sq. yd. are cleaned by hand sweeping under the patrol system. The districts for each sweeper vary from 3,200 sq. yd. in the business district to 17,000 sq. yd. in the residential sections.

In addition to the sweeping service, all paved streets are cleaned with water periodically. This is done with Studebaker flushers and auto flushers. One hundred and forty miles of streets were flushed. In the retail district the streets are flushed every night. In the outlying districts flushing is done as required.

Fifty-nine miles of streets were water sprinkled for the entire season; 207 miles were treated with oil; this includes streets which were water treated the early part of the season and then oiled.

The rate for water sprinkling, four trips per day, was 13.8 ct. per frontage foot or $5.52 for a 40-ft. lot, for the season. The rate for oiling, two oilings per season, an average width of 24 ft. was 4.8 ct. per foot, or $1.92 per 40-foot lot. The oil is distributed by Kinney auto oilers, using 834,985 gal. of road oil.

Where dust was laid by flushing the following rates were used:

	Per Frontage Foot
Night flushing, daily	15 ct.
Flushing every five days	3 ct.
Flushing twice a week	5 ct.
Flushing once a week	2½ ct.

Fifty-eight thousand one hundred and twenty-nine lots or parcels of land were assessed for sprinkling and oiling. Some of the lots were assessed for both, making a total of 92,566 separate assessments. The cost of spreading this assessment per lot or parcel was $0.074 and the cost for each assessment $0.047.

How Pennsylvania Allots Its Highway Funds

The estimated total expenditure by the Pennsylvania Highway Department from general and special funds and federal aid for the two years, June 1, 1925-May 31, 1927, amounts to $117,018,129. According to a bulletin issued by the department this sum has been apportioned as follows:

Maintenance and replacements on State Highway System	$38,873,268
New construction on State Highway System	41,226,512
Administration, including motor license collection costs	6,024,000
Sinking fund and interest on Highway Bonds	10,307,800
Rebuilding inter-county bridges destroyed by fire	399,056
State reward on township highways	3,125,646
State aid for county, township and borough highway construction	17,061,847

The state highway system embraces 10,274 miles, of which 3,953 miles are primary highways, and 6,321 miles are secondary highways. Up to Jan. 1, 1926, approximately 7,300 miles of the total of 10,274 had been improved with some type of pavement. In addition to the state highway system, the department maintains 562 miles of hard-surface state-aid roads, off highway routes, and pays half the cost of this maintenance.

The 1925 Legislature, in passing what was known as the Omnibus Road Bill, added approximately 1,200 miles to the state highway system. This mileage, which is almost entirely of earth roads, was taken over June 1, 1926, and makes a total of more than 12,000 miles of highway to be constructed and cared for by the state.

Saving Old Block Pavements

Method of Surfacing with Sheet Asphalt at Alliance, O.

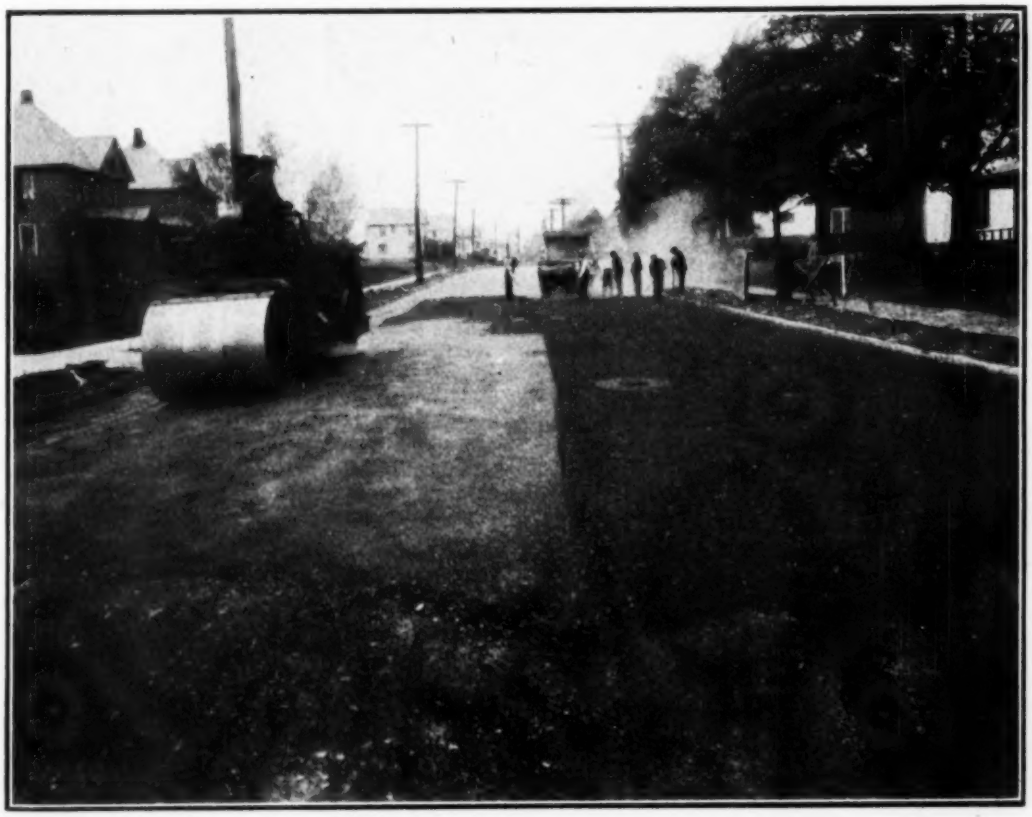
By H. E. ANDERSON,
City Engineer, Alliance, O.

There are thousands of yards of old block pavements in cities of this country, which, due to increased traffic in both volume and weight, have not been able to hold their original contour. They have developed numerous depressions which are not serious from a traffic standpoint, yet they bring frowns from the automobilist who is compelled to use the thoroughfare.

To take up the present block and relay them would be quite expensive and besides it would be necessary to reconstruct the base so as to provide a foundation which could carry present day traffic. The city of Alliance has several streets typical of the above description and after considerable investigation the engineering department recommended that a sheet asphalt surface be placed over the old block.

Some preparation must be made, however, to the old block pavement before placing the top. Our specifications provide for first rolling the old pavement with a 10-ton roller to discover any weak places in the old foundation. Such weak places are filled with concrete flush with the top of the old block. All old ditches are carefully examined if they show signs of settlement, and are also concreted in.

Practically all of our old block pavements were laid on bank run gravel base with little if any underdrains, so that it is necessary to investigate this condition. If not originally provided, we install a 4-in. underdrain beneath the old gravel base, filling the ditch with slag, and concreting the upper part as above. This item is of the utmost importance and lack of consideration for it, I believe, is responsible for what would otherwise be good resurfacing construction. After the foundation has been made secure the street should be thoroughly swept with brooms and flushed with water to



Surfacing of Old Block Pavement on South Union Ave. with Asphalt.

View of South Union Ave., Showing Condition of Old Pavement Before Surfacing.

remove all dirt and debris. All depressions of any consequence, and over 2 in. in depth, should be filled with asphalt binder and carefully tamped or rolled into place, so as to provide uniform compression in the binder course. The binder course should be 1½ in. in thickness as a minimum over the quarters and crown of the street, and exceeding that amount to provide a uniform surface where slight depressions exist. The binder can be raked to 1 in. depth at the gutter line so as not to reduce the effective depth of the original gutter. Following the placing of the binder, a sheet asphalt wearing surface of 1½ in. in depth should be placed and rolled carefully to the finished surface of the street.

The city of Alliance is at present resurfacing South Union Ave. which was originally constructed in 1906 with sand filled block on a gravel base. This street is one of our main highways and carries an enormous amount of inter-city traffic. The surface of the street

Completed Asphalt Wearing Surface on South Union Ave.

was very rough and the popular demand was for a uniform smooth surface. This resurfacing, as well as our new paving is being constructed by the General Asphalt Paving Co. of Canton, O., using Texaco asphalt. The plant and street inspection is handled by the H. C. Nutting Company of Cincinnati, O.

I might add at this point, that starting with last year's construction of new paving, that a light wire mesh of 28 lb. per 100 sq. ft. is being installed in the concrete base, using a 1:2½:5 mix. The new sheet asphalt construction of last year using the reinforced concrete base has gone through the rigors of the 1925 winter without any cracks developing or making their appearance in the asphalt top, this demonstrating to my satisfaction the advisability or reinforcing the base and preventing the base cracks from extending through to the asphalt top.

New Bottom Dump Trailer

A new bottom dump trailer designed especially for use with tractors has been placed on the market by The Miami Trailer-Scraper Co., Troy, O. The unit also may be used with trucks providing the speed of the truck is held down to about 10 or 12 miles per hour.

The trailer is of all-steel construction. The

Regular 1½ yd. Trailer.

all-steel wheels are each equipped with two Timken tapered roller bearings. The rear wheels are 40 in. in diameter with a 7 in. face tire. The chassis frame is of 6 in. rolled steel channel weighing 10½ lbs. to the foot. Suitable risers and braces are so mounted as to keep the rear axle rigid under the load. The spindles are steel, cast hollow or cored. The spindle castings are riveted to the 4 in. I-beam center section of the axle. The Timken bearings used are of the tapered type and provide fully against end thrust both inward and outward. The wheel hubs are machined to very close limits for Timken bearing equipment, a felt washer being mounted in the groove on the inside shoulder of each spindle and a hub cap fitted to the outside hub flange insuring a fully dirt proof hub. The lubrication of the wheels is accomplished through Alemite nipples making it unnecessary to remove the wheels except for the occasional cleansing of the Timken bearings.

The drawbar is constructed for attachment at any height so that these trailers may be coupled in trains of two or more by mounting a towing hitch connector to the rear cross member of each trailer. The body construction of this unit is stated to be unique, the dumping doors being hinged directly to the chassis frame or channel. This construction results in a very low loading height, the distance from the ground to the top of the body being only 56 in. in the 1½-yard trailer and 61 in. when equipped with a 5 in. top box. The winding and dumping device is located at the front end of the trailer on the right hand side. The dumping lever is so constructed that it may be operated from the tractor driver's seat by means of a rope. The winding lever will close the doors in less than five seconds time.

The trailer is regularly furnished in the 1½-yard capacity water level, loading 2 cu. yds. crowned 12 in. in the center. When equipped with an extra ½-yd. top box the water level capacity is 2-cu. yds. and 2½-cu. yds. crowned load. The body, the bottom doors, as well as the winding and dumping device are so constructed that they can easily be removed from the trailer chassis giving a chassis on which can be mounted a platform body for general hauling purposes. The trailer thus becomes a two in one unit.

New Reduction Gear for Use with Climax Engines

The Engineering Department of the Climax Engineering Co., Clinton, Ia., has developed a 3½ to 1 reduction gear for use with Climax gasoline engines, models "TU," "R4U," and "R6U."

The newly designed speed reducer consists essentially of a compact set of heat treated, cut gears, enclosed in an oil proof, dust proof housing which is bolted to the flywheel housing of the engine. The high speed shaft and the low speed shaft rotate in the same direction. These gears run in oil and are designed to operate with a minimum of noise.

The reduction gear unit embodies a Twin Disc clutch, thus allowing the engine to be started independently of the load. The load is thrown on after the engine is in operation. The driven unit may be connected by flexible coupling or by belt to the power unit.

Earth Road Construction

Methods of Grading in Saskatchewan Described in Paper Before Canadian Good Roads Association

By H. R. MacKENZIE
Chief Field Engineer, Saskatchewan Department of Highways

During the past six years we have constructed under engineering supervision 2,400 miles of high standard earth roads on the provincial highway system of the province of Saskatchewan.

Dealing with actual grading operations, I will refer very briefly to some of the features which our inspecting engineers have found necessary to emphasize. We are constructing 400 to 450 miles of road on our provincial highways system each season, and as the work is distributed over the entire province we, of necessity, must engage a large number of contractors. We were not long in learning that there was a vast difference in the value of the finished work on contracts performed under the same plans and specifications, and at the same unit prices. Roads that apparently were built to the same standard were found to differ materially when subjected to traffic and the consolidating action of rain and frost. In order that settlement in a fill may take place uniformly, it must be of uniform density throughout, and this means that care must be taken in depositing and consolidating the material throughout the entire height of the fill, instead of simply making a smooth surface on a fill composed of rocks, sods, brush and earth, indiscriminately assembled.

Grading Methods.—Most of our grading work is done by fresnos, or with elevating graders and dump wagons. The slush scraper or the wheel scraper is rarely used. If the material in the fresnos is spread while dumping, and, if the dump man in charge of a grader outfit judiciously places the material from dump wagons, the constant use of a "mormon," or a 4-horse grader, on the dump during construction to further level and spread the material, will result in the building of a fill that will settle uniformly and consequently maintain a smooth surface.

Another feature that requires careful attention, in order to eliminate waves in the consolidated road, is adequate provision for settlement in embankments. When a uniform gradient extends through a cut and across a fill, the fill must be built sufficiently high above the profile elevation, so that when settlement takes place the consolidated fill may be true to grade.

Safety Features of Roads.—With regard to safety features in the design of the road, we are using 3 to 1 slopes on all fills averaging 4 ft. or under, and are protecting by guardrail the fills in excess of 4 ft. in height, these fills being built with 1½ to 1 slopes, excepting when subject to wave wash. The inside slope of all ditches adjacent to the roadway is also 3 to 1, and 3 to 1 back slopes are used whenever the width of right-of-way will permit, so that at all points not protected by guardrail or motor car or other vehicle, may at reasonable speed run into the ditch or down the slope of a fill without danger of upsetting. The easy side slopes also increase the effective width of the roadway by permitting traffic to utilize the entire width of the road surface in safety.

Most of the road allowances in Saskatchewan are 66 ft. in width, but fortunately a portion of Eastern Saskatchewan was surveyed before the width of roads was reduced from 99 to 66 ft. It is very difficult to build a safe 20-ft. road on a 66-ft. right-of-way, when the effective width of right-of-way is reduced to 54 ft. by a telephone line on either side, and it certainly is not feasible to secure the material required for the average mile of road, namely 6,000 cu. yds., from borrow pits within the limits of the right-of-way. We do not permit borrowing in depressions on the right-of-way and, as all borrow pits must be drained, they are not excavated below the level of the side ditches. Care is taken to see that borrow pits are not located at curves or other danger points on the highway.

In the case of a road being constructed in a prairie area where the soil is liable to drift, it has been found that the side ditches are usually blocked during the spring when they are most urgently needed, and consequently in such cases it is necessary to construct a continuous embankment of a height of from 18 in. to 24 in. above the natural surface, even on high land with good natural drainage. This type of road can be built by side casting, providing care is taken to avoid borrowing in sags, and that each layer of material deposited by the elevating grader is broken up and spread before further material is deposited thereon.

Drainage.—The transverse surface drainage of the road is taken care of by the crown, and one of the most dangerous features of earth roads is being eliminated by the adoption of a sane and adequate crown height of 4 in. to 6 in. on a 20 ft. road, instead of the still too prevalent peaked-roof type of road. The drainage of the right-of-way is much more important and much more difficult than the drainage of the road surface.

It is not good practice in this climate to

carry a drainage ditch through a cut, for at the time of the spring run-off, the cut ditch is often blocked with snow and ice and an off-take ditch or culvert should be substituted for a ditch through a cut.

We use pipe culverts of metal or concrete for openings of 12 in. to 36 in. diameter, but it is a serious mistake to suppose that these culverts can be properly installed by rolling them in place and covering them with sods, stones, brush, or other available refuse. They should be installed on a properly prepared bed, so that the culvert is supported uniformly throughout its entire length; they should be placed so that the water flows with the laps, and should have a fall down stream of ¼ in. per foot of length. The earth should be thoroughly tamped around the culvert to prevent erosion, and they should be protected by a covering of at least 12 in. of consolidated material.

Court Again Sustains McMichael Patent for Pneumatic Concrete Placer

The Concrete Mixing & Conveying Co. has recently won a decision in the United States District Court, Southern District of New York against Powers-Kennedy Contracting Corporation and Anthony G. Fleck restraining their use of what is known as the McMichael Patent for pneumatic concrete placers.

This new case, as the decision of the court reads, "is an attempt to re-try the issue determined in the case of Concrete Mixing & Conveying Co. v. Ulen Contracting Corporation, 12 Fed. (2d) 929; 931. The main reliance is upon a prior use which is alleged to have occurred over 20 years ago. No contemporary sketches are produced and the two witnesses attempt to describe from memory a mechanism which was not used except on two occasions. If such a practical device as that of the patent in suit had been employed, it is hardly likely that a contractor used to conducting large enterprises would not have sought a patent, or at least have taken advantage of something which in recent years has met with signal success. I am not satisfied that the defendants have established the prior use."

Regarding the McMichael Patent an excerpt from the Court's original decree is both interesting and enlightening: "The appreciation by the inventor of the necessity of limiting the concrete to be conveyed to sections of moderate size and weight and his method by the second air jet of securing the cutting off of a segment from the mass of concrete and a propulsion of this segment through the discharge pipe involves invention of a high order. His device has displaced all other methods for rapidly and economically conveying, lifting and placing concrete at long distances from the initial source of supply and has been used in numerous great enterprises."

Pan American Engineers on Road Convention Program

Speakers representing five Pan-American nations will feature the program of the meeting of highway officials, contractors and engineers to be held in Chicago during Good Roads Week, Jan. 10th-15th. The official delegations from South and Central American countries will discuss highway problems on the third day of the meeting, Wednesday, January 12th.

The road congress is the 26th Annual Convention and Road Show of the American Road Builders Association and is expected to draw an attendance of 40,000 from all parts of the American continents. The Pan-American Day program will be presided over by F. Diaz Leal of the Mexican Government in co-operation with Col. R. Keith Compton, Director of Public Works, Richmond, Va. Other Pan-American Speakers include:

B. Gonzalez Cohen, Chilean Office of Foreign Affairs, Santiago, Chile; Manuel Alberto Coroalle, Department of Public Works, Havana, Cuba; Manuel Gonzalex Durand, Argentine Consul to the United States, Buenos Ayres, Argentina; and Dr. M. Vellarde, Peruvian Ambassador to the United States.

Marcelo T. de Alvear, President of the Argentine Republic is expected to appoint additional delegates to attend the meeting and participate in the program. The same is the case with the President of Peru. All the nations will have exhibits demonstrative of the highway systems in their respective domains.

In addition to the nations active on the program of the American Road Builders Association Convention, delegations are expected from every other country of South and Central America.

Annual Meeting of Street Sanitation Officials.—The annual conference of the International Association of Street Sanitation Officials will be held Jan. 10 and 11 at the Statler Hotel, St. Louis, Mo. A. M. Anderson, 10 South La Salle St., Chicago, Ill., is secretary of the association.

Traffic Control in Chicago

One of the most far-reaching and inclusive programs of traffic control ever effected in the United States is soon to be undertaken in Chicago, where plans are under way to bring the entire Chicago metropolitan area under a single unified system of regulation.

That the program is one of the largest ever attempted is indicated by the fact that the area embraces a population of more than 4,000,000 people and includes portions of two states, six counties, 50 cities with a population of more than 2,500 each, and 109 towns and villages.

For the past ten months this area has been the subject of an intensive scientific traffic survey instituted by the Chicago Association of Commerce and carried on by the Albert Russel Erskine Bureau for Street Traffic Research under the direction of Miller McClintock, a nationally known traffic engineer and director of the Erskine Bureau, recently endowed in Harvard University for the purpose of studying the increasingly complicated aspects of street congestion.

"More than 125,000 vehicles a day pass between Chicago and the six counties included in the metropolitan area, and approximately 250,000 vehicle movements a day are exchanged between Chicago and immediately adjacent communities," said Mr. McClintock, commenting on the movement to unify the area's traffic control. "Nothing short of chaos and congestion can be expected if each of these hundreds of thousands of drivers finds himself operating under a different system of control every time he crosses a political boundary. Unification of a method of traffic control throughout the Chicago area will help all concerned,—the communities now troubled with traffic problems and the motorists who pass through these communities."

Mr. McClintock points out that safety and convenience on the streets and highways depend on orderly use and orderly use depends on general understanding and obedience to fixed rules of operation. Thus a primary requirement for traffic relief in a metropolitan area is to be found in a basic code of street use designed to lessen congestion and accidents and reduce friction and conflicts. The qualities or factors of a good traffic code are outlined briefly by Mr. McClintock as follows:

"The code must be simple. People do not have time nor the inclination to memorize a lot of laws and rules. It must be enforceable. It must be comprehensive and in comformity with the natural requirements of traffic. Flexibility is another factor found in a good traffic code as street conditions often change rapidly so the code must be adaptable. It must be based upon facts regarding street use as the day of haphazard methods of street control are gone. Traffic regulation is a science. Finally, a traffic code must be balanced. There should be a delicate and accurate adjustment between the requirement of people to move over the streets and maximum safety of use."

That these qualities are workable ones is indicated in their success in Los Angeles and its adjacent suburban territory where a traffic code designed by Mr. McClintock along the above lines is now in effect. According to the data compiled by Los Angeles before and after the installation of the code accidents have been reduced 30 per cent and street capacity increased up to 50 per cent through the operations of the code.

Milwaukee Railway's Motor Coach Fleet

City and interurban motor coaches have been operated by the street railway and light company of Milwaukee since the summer of 1919. Automobiles and motor trucks have been operated by it for a considerably longer period. The fleet has grown steadily until now it includes 175 automobiles and motor trucks that make about 100,000 miles a month and 141 motor coaches whose monthly mileage is close to 400,000, said Henry L. Debbink, superintendent of gasoline vehicles for the company, at a recent meeting of the Milwaukee section of the Society of Automotive Engineers.

The modern motor coach must be able to run from 40,000 to 60,000 miles annually for four or five years at a reasonable operating cost. To prevent road delays so far as possible and still keep maintenance costs reasonable, many changes in maintenance methods were necessary from time to time, said Mr. Debbink.

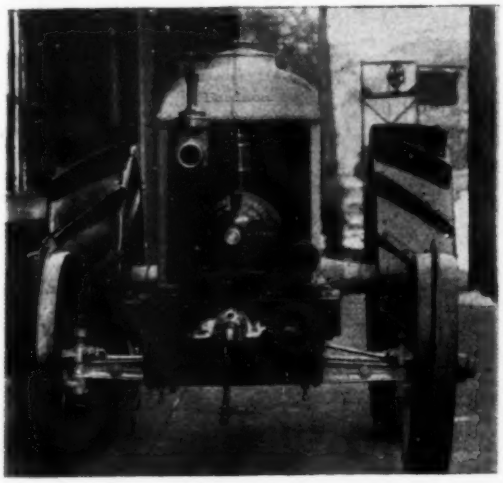
Under the present system the oil is drained from the crankcase after each 1,000 miles, the chassis is greased and those parts that give most frequent trouble are inspected. This inspection is made between runs or at night and can be completed by a mechanic and a helper in 45 minutes. A general inspection is given after each 4,000 miles and a general overhaul of chassis and body at intervals averaging 30,000 miles. Overhaul of the chassis requires from three to six days and the body overhaul and painting from five to seven days. In general the four-cylinder engines are changed at every other overhaul, or between 50,000 and 60,000 miles. The newer 6-cylinder engines give indications that they will need to be changed at the third and in some cases at the fourth overhaul.

More than 800,000 gal. of gasoline and 30,000 gal. of lubricating oil are used per year. The gasoline is bought in tank car quantities and storage facilities for 1,000,000 gal. are provided so that the fuel can be bought when the price is low and stored for use when it is high.

Pump on Tractor Supplies Water for Paving Job

On one of the R. D. Baker Construction Co.'s paving jobs on the super-highways leading out of Detroit, water was needed a mile away from the nearest source, which was a hydrant.

Upon turning on the hydrant they found the pressure was so weak that it would not even lift the water up into a tank or barrel. So they tried out the plan of mounting a Jaeger-Goulds pump on their tractor. With this they were able to do away with the expensive operation of hauling water for use a mile away in tank wagons. This was done by laying a mile of pipe, then connecting up the Jaeger-Goulds pump installed on the tractor with the hydrant and pipe line. They have also found this works equally well when they have to take their water out of a stream or ditch, because of the high pressure developed by the pump. With this method, the construction company finds they are able to have adequate water supply transported from various distances up to a mile or more at a fraction of the previous cost.



Pump Mounted on Tractor for Supplying Water for a Paving Job.

Military Engineers Members of Highway Research Board.—At a recent meeting of the Executive Committee of the Highway Research Board, the Society of American Military Engineers was admitted to membership on the board. The membership of the society totals about 6,000 active engineers, practicing in every state of the Union, in all territories and our overseas possessions, and in twenty-five foreign countries.

Maine Bulletin on Mortar Strength.—"Relation of 7-Day to 28-Day Compressive Strength of Mortar and Concrete" is the title of Bulletin No. 17 by John W. Gowen and H. Walter Leavitt, issued by the Maine Technology Experiment Station. This bulletin is a reprint from the 1926 Proceedings of the American Concrete Institute and gives the discussion by the authors of paper presented at the last annual meeting of the Institute by W. A. Slater of the U. S. Bureau of Standards.

S. A. E. Membership Is Over 6000.—The membership rolls of the Society of Automotive Engineers now contain 6,052 names, including several hundred foreign members, according to a report made at a recent meeting of the council of the society in New York. This number compares with 5,277 on November 7, 1925, and shows a net gain during the twelve months of 775 members. In the period from Jan. 1 to Nov. 6, 1926, 760 applications for membership were acted upon and 698 of those elected qualified as members.

1,900 Mile Road Program in New Jersey.—At the coming session of the New Jersey legislature in January, the state highway commission will submit a proposal for a road system to embrace all of the 21 counties. The system would take ten years or more to complete. The 1926 Legislature asked the board to make recommendation for about 2,000 miles of primary and secondary routes and the report just completed is the result.

Sand and Gravel Convention in January.—The 11th annual convention of the National Sand & Gravel Association, Inc., will be held in the Gibson Hotel, Cincinnati, O., Jan. 17, 18, and 19, 1927. For the first time, exhibits of equipment and machinery will be permitted. Fred E. Hall is chairman of the convention committee with offices at the association's headquarters in Washington.

Highway Construction in Spain.—The Council of Ministers of Spain have approved the immediate construction of 55 highways. The cost of this work will amount to $2,416,000 and another group of 193 highways is to be built at a cost of $8,513,004.

Meeting of Paving Brick Manufacturers.—The 8th Annual Meeting of the Eastern Paving Brick Manufacturers' Association will be held Dec. 14th, at the Hotel Washington, Washington, D. C. Wm. C. Perkins, Lincoln Building, Philadelphia, is secretary.

New Trade Publications

The following trade publications of interest to highway officials, engineers and contractors have been issued recently. Copies of them can be obtained by addressing the firms mentioned:

Concrete Heaters—The Hauck Manufacturing Co., 126 Tenth St., Brooklyn, N. Y., has issued a bulletin illustrating and describing the application of its concrete heaters to Jaeger and other tilting type mixers.

Tractor in Snow Removal—A folder on the use of its tractor in snow removal has just been issued by The Cleveland Tractor Co., Cleveland, O. It contains an account on the use of the tractors at Garden City, N. J., together with numerous illustrations of the tractor equipped for snow removal and engaged in the work.

Traffic Signals and Signs—Specifications and drawings for Interflash traffic signals and signs, have been issued by the Interflash Signal Corporation, 120 Broadway, New York City. These signals and signs comply in all particulars with the standards adopted by the American Association of State Highway Officials and approved for use on all Federal aid highways by the U. S. Bureau of Public Roads.

Hydrated Lime as Filler in Asphalt Paving Mixtures—"The Value of Hydrated Lime as a Filler in Asphalt Paving Mixes," is the title of a bulletin just issued by the National Lime Association, 927 15th St., N. W., Washington, D. C. Extensive research work conducted by Prevost Hubbard and F. C. Field of the Asphalt Association, are presented for the first time in this bulletin.

Snow Removal—A revised edition of its handbook of snow removal has just been issued by The Good Roads Machinery Co., Kenneth Square, Pa. The following table of contents will give an idea of what the book contains. Snow Fall Map, Growth of Snow Removal, Snow Fall Has Not Decreased, Basic Conditions of Snow Fall, Weather Bureau Field Stations, Organizing for Snow Removal (State Organization, City Organization, County Township and Borough), Equipment for Snow Removal, Procedure in Snow Removal (In the Country, In the City, Light Snow, Method of Plowing Wide Streets, Crosswalks, Sanding, Ice Scarifying, Drains and Gutters, Sidewalks), Drift Prevention (Snow Fence, Location and Grade), Private Effort at Snow Removal (Bus Companies, Truck Transport Companies, Industrial Plants, Contractors, Institutions, Farmers, Civic Organizations), The Cost of Snow Removal, Condensed Catalog of Good Roads Snow Plows, U. S. Survey of Snow Removal Data.

Road Graders—A folder illustrating and describing its new motor controlled grading machines has been issued by the Ryan Manufacturing Corporation, 310 South Michigan Ave., Chicago, Ill. The various illustrations show details of the machine and the text describes the important features.

Pavers—A new 48-page catalog devoted to its pavers has been issued by the Koehring Co., Milwaukee, Wis. The various features of the machine are illustrated and described, and specifications and general dimension drawings are given.

of the results of the tests conducted at the Carnegie Institute of Technology. The publication also includes a description of the single and multiple operator arc welding equipment, the gas engine driven and the portable belted generator equipment and the Westinghouse auto arc.

Copper Alloy Steel.—"Copper Bearing Steel Resists Corrosion" is the title of a treatise issued by the Truscon Steel Co., Youngstown, O., containing facts, figures and photographs on the rust-resisting properties of steel containing a percentage of copper. This 15 page treatise was compiled by Robert D. Snodgrass, Consulting Engineer.

Industrial Notes

The Sale and Service of Multi Foote pavers will, in the future, be handled by the Multi Foote Sales Co. at 2811 West Fulton St., Chicago. This concern is headed by M. Clarence Dunkle who has long been connected with the Foote Co. and is thoroughly familiar with the history and manufacture of Foote pavers. The Multi Foote Sales Co. is equipped to service pavers that have long been in the field as well as the latest models. This includes a first class machine shop and expert assistants as well as a complete list of Timken bearings and kindred parts which bear the Foote life guarantee.

The Link-Belt Co., Chicago, Ill. to maintain a closer contact with its friends in the New Haven territory, and to service the better its increased amount of business in that district, has established temporary headquarters in New Haven, Conn., at 152 Temple St. R. H. Hagner, formerly of the Philadelphia office, will be Link-Belt's representative in this, their 36th office, which will be devoted especially to the sale of Link-Belt Silent Chain and Link-Belt Roller Chain.

Joseph T. Ryerson & Son, Inc., have purchased the warehouse division and property of the Bourne-Fuller Co. at Cleveland. The Bourne-Fuller Co., already large steel producers, will concentrate on their business of manufacturing their steel products. The property consists of a group of large modern warehouses, with 200,000 sq. ft. of ground area. The plant is stocked with a complete line of bars, shapes, plates, sheets, and steel products, totaling about 12,000 tons in all. The Ryerson Co. will at once add to the facilities and increase the size and range of stock carried. They will also add other products to complete the line. This will be the ninth Ryerson Plant. The others are located at Chicago, Milwaukee, St. Louis, Cincinnati, Detroit, Buffalo, Boston, and New York.

The Buda Co., Harvey, Ill., makes the following announcement: John P. Mahoney has been appointed executive engineer, in charge of all engineering for the automotive, power plant and industrial divisions. Mr. Mahoney, who formerly directed the sales of these divisions, will also have general supervision of service activities with Walter Petty, formerly chief engineer of the Service Motor Truck Co. and the Maccar Truck Co., in active charge as manager of the service department. Guy B. Wright, as sales manager of the automotive division, will have charge of sales in the bus, truck, taxicab and marine divisions. R. K. Mangan, as sales manager of the industrial and power plant divisions, will have charge of the sales of these two divisions.

The H. O. Penn Co. Inc., construction and industrial equipment, has been formed as successor to the Ginsberg-Penn Co., Inc., H. O. Penn having purchased the interest of Frank I. Ginsberg in the Ginsberg-Penn Co., Inc. The H. O. Penn Machinery Co. will continue to represent the same manufacturers of construction equipment, that is, Chain Belt Co., Byers Machine Co., Link-Belt, Butler Bin Co., Domestic Engine & Pump, Beach Mfg. Co. and others. The same personnel remains with the new company with the exception of Mr. Ginsberg who has entered into the general contracting busines.

W. D. M. Allen has been appointed manager of the Cement Products Bureau of the Portland Cement Association, effective Nov. 1. He succeeds A. J. R. Curtis who became assistant to the general manager of the association on the same date. Mr. Allen who is widely known in the building and cement products field has been engaged in the promotion of concrete products for the past seven years. Formerly he was a member of the Cement Products Bureau Staff, but more recently he served as office manager of the Illinois District Office of the association.

The Chain Belt Co. of Milwaukee, manufacturers of Rex mixers and pavers, Rex elevators and conveyors, Rex chain and transmission parts, announces the appointment of three new distributors for their Rex mixer line: In Clarksburg, W. Va., The West Virginia Mine Supply Co. will handle a territory composed of that portion of the state of West Virginia bounded by and including Wetzel, Tyler, Pleasant, Worth, Calhoun, Braxton, Webster, Pendleton, Hardy, Tucker, Preston, Monongalia, and Hampshire counties. The Builders Supply Co. of Shreveport, La., will handle the Rex mixer line throughout the northern half of Louisana, and the Geo. R. Feldmann Co., has been given the territory in and around Wilkes Barre, Pa. These companies carry the Rex tilter, 5 S, 7 S, 14 S, 28 S, 27 E.

The Kent Machine Co., of Kent, O., announces the appointment of C. R. Ott as Florida District Manager, with headquarters at Orlando, Fla.

Direct Factory Branches or Affiliated Representatives in 66 cities

*Albany
*Allentown
Altoona
*Atlanta
*Atlantic City
*Baltimore
Binghamton
*Boston
*Bronx
*Brooklyn
*Buffalo
*Camden
*Canton, Ohio
*Charlotte
*Chester
*Chicago
*Cleveland
Columbus
Cumberland
*Dallas
Denver
*Detroit
*Erie
*Fall River
*Fresno
Harrisburg
*Indianapolis
*Jersey City
Lancaster
*Lawrence
*Los Angeles
*Memphis
Miami
*Newark
*New Bedford
*New Haven
*New York
*Norfolk
*Oakland
*Paterson
*Philadelphia
*Pittsburgh
*Providence
*Reading
*Richmond
*Rochester
*Sacramento
*San Diego
*San Francisco
*San Jose
*Schenectady
Scranton
Shamokin
*Springfield
*St. Louis
*Stockton
*Tampa
Utica
*Washington
West Palm Beach
Wheeling
Wilkes-Barre
Williamsport
*Wilmington
*Worcester
York

*Indicates Direct Factory Branch

Autocar performance is a deciding factor

Many companies have decided to purchase their first Autocar as a result of the following investigation: Selecting some names of Autocar users (taken at random from the large list published in the Autocar Road Building Booklet) they wrote the owners, asking for their opinion of Autocar performance.

It is one of the best and most impartial ways of making sure that you are buying the truck that will do your work economically. For contractors and road builders who use Autocars know from their cost records the economies effected by Autocar sturdiness, Autocar short wheelbase handiness and the Direct Factory Branch Service behind the truck.

Try this test yourself by writing us for a free copy of "Autocar Trucks for Building Roads."

The Autocar Company, Ardmore, Pa.
ESTABLISHED 1897

Autocar Trucks

Wherever There Are Roads to Build

How Paver Dollars Can Buy *as High as* 40 More Minutes

WITH Rex *Unified Action*, the dollars you put into mixing concrete can buy as high as 40 minutes more work per nine-hour day.

In other words, when you stop your Rex 6-bag (1-2-4) 27-E at 5:00 o'clock it has as much fresh pavement behind it as if you had worked until 5:40 without unified action.

Fastest Mixing Cycle

With average plastic concrete, Rex *Unified Action* makes it possible to complete the mixing cycle in eleven seconds over the required mixing time.

This is largely due to the fast discharging action which permits the operator to throw in his skip clutch at the same time that he opens the discharge.

Three Operations in Unison

Charging, discharging and getting water into the drum are synchronized to a point where all three can be accomplished at the same time.

By the time the skip reaches its initial charging position the discharging operation is completed. Then the loose material and water go in together

Up to 40 Minutes a Day Saved

As fast as the mixed batches are discharged they are replaced by fresh aggregates. The drum is working all the time.

And the time saved often totals as high as 40 minutes for a nine-hour day.

Get This Book

The latest Rex Paver Booklet, entitled, "*More Yards Per Day*", has all the facts on Rex *Unified Action* for you.

And it tells about the new 7-second water system which has stopped mixing penalties and water hold-ups.

Send for a copy today.

REX PAVERS

CHAIN BELT CO., 731 Park Street, Milwaukee

SUCCESSFUL PERFORMANCE KEY ACC-A

Check these things on the job or in the booklet:—the time required to get the aggregates into the drum—that the water goes into the drum in the same time as the other aggregates—the ability of the mixing blades to take away the carrying capacity of the 10 big mixing buckets—the 6-second discharge time—and the sturdiness of flex construction.

Digging and Loading with a Minimum of Equipment and Men

The above picture shows a complete digging and loading layout that is working a small South Dakota gravel pit successfully and cheaply.

A Barber-Greene "42" Bucket Loader handles all of the digging. It delivers to the Barber-Greene "N" Portable Conveyor, which in turn loads the gravel directly into trucks. The number of trucks shown in this early morning picture will give you some idea of the yardages handled.

Shovel labor is cut to two men in addition to the loader operator. And there are no permanent, expensive units—and no teams and slips.

When the two Barber-Greenes have finished this job they can be quickly and inexpensively moved to another. This same "42" Loader, for example, was used to take oversized boulders out of a scarified highway, by loading over a grizzly screen.

This exceptional versatility is one big reason why Barber-Greene Equipment shows such remarkable cost per yard records. The "42" Loader, for instance, will load any loose or semi-loose bulk material. It can be swung from pit work to loading and batching for road work—or to loading loosened sub-grade or strippings—or anyone of some 20 different jobs.

The "N" is equally versatile. It is an ideal machine for unloading directly from beneath hopper-bottomed cars—for building stock piles—for loading trucks or railroad cars.

The low Barber-Greene costs can be written off over a number of jobs—and Barber-Greenes are so versatile that they can handle practically any material handling job, *at a profit*.

The coupon will bring you your copy of *Contracting with Barber-Greenes* with its complete details on what Barber-Greene Loaders and Conveyors are doing—and how inexpensively they are doing it. Send the coupon today.

Barber-Greene Company,
518 West Park Ave., Aurora, Ill.

Here's my ticket for the inspection tour of material handling layouts through "Contracting with Barber-Greenes." Send me a copy.

See 1927 ROAD SHOW JAN. 10?

Name.....

Address.....

City.....State.....

BARBER-GREENE CO.—*Representatives in fifty cities*— 518 W. Park Ave., Aurora, Ill.

BARBER GREENE

Portable Belt Conveyors — Self Feeding Bucket Loaders

Coal Loaders . . . Automatic Ditch Diggers . . Coal Feeders

"It has been in service every day (*for ten months*) and has not been in the shop yet"

That's what the operator of one "AMERICAN" Model "K" Gasoline Shovel was able to say; and his machine was engaged in unusually hard digging and heavy going in a heavily wooded part of Oklahoma.

The certainty that your shovel will continue to deliver its usual daily yardage day in and day out should mean a lot to you in the way of increased profits. You can bank on the "AMERICAN" Model "K" Gasoline Shovel to do that.

A copy of our new Gasoline Shovel Book is yours for the asking.

AMERICAN
HOIST & DERRICK CO.
Saint Paul, Minn.

New York. Chicago, Pittsburgh, Seattle, St. Louis. New Orleans

If You Had to Pay for a Crawler Out of the Profits of ONE Job, You'd Buy a Link-Belt

NATURALLY, you would want a crawler that would give you the most service, dollar for dollar.

No other machine has the features that make Link-Belt Crawlers "the best that money can buy"—here they are—compare them—

Fewer gears—less moving parts.

Oversize working parts.

Exceptional strength without undue weight.

One piece, open hearth steel, rotating base.

One piece, open hearth steel lower frame.

Self-cleaning, special chrome steel crawler treads.

Large easily removable rollers.

Extra heavy cut gear drive on lower frame, fully enclosed in oil tight casings.

One piece steel rotating gear and roller path of very large diameter, integral with center pin bearing.

Learn more about this powerful machine by requesting a copy of Book No. 895—It's interesting.

See us at the Chicago Good Road Show, Jan. 10-14, 1927
Some territory still open for Agents. Get our Proposition

LINK-BELT COMPANY 2793

Leading Manufacturers of Elevating, Conveying and Power Transmission Machinery

CHICAGO, 300 W. Pershing Road — Offices in Principal Cities

LINK-BELT

"Built for Service" CRAWLER

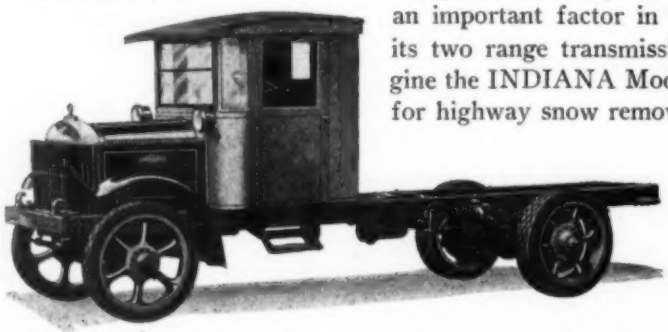
MOTOR INDIANA TRUCKS

The choice of hundreds of Highway Commissions

17 years at it! Proved by Proofs

Indiana Model 126—3-Ton Chassis is especially adapted to Road Building, Construction and Maintenance work. Detailed specifications furnished on request.

TWENTY-FOUR State Highway Commissions and hundreds of County commissions throughout the country have chosen INDIANA TRUCKS for their road construction and maintenance work throughout the year, including Snow Removal, which is an important factor in highway work. With its two range transmission and powerful engine the INDIANA Model 126 is the ideal job for highway snow removal work.



Wouldn't you like to know just where Indiana Trucks are in use? Write for a copy of handsome booklet—"Fleets of Indiana Trucks."

INDIANA TRUCK CORPORATION, MARION, IND.

Makers of One to Five Ton Motor Trucks

Waukesha Equipped Clyde "Gasoline Donkey" out in Oregon

Down 62% Grades

Pulling themselves up and down over almost impossible grades and at such angles that only a 100 H. P. Waukesha Equipped Clyde "Gasoline Donkey" could operate is one of the daily tasks of these units. One handled a 2½ yard bucket grading and chunking out continuously for 238 days on double shifts and was only stopped two days at Christmas.

If you have unusually severe conditions to meet, you will find Waukesha "Ricardo Head" Industrial Power Units are particularly adapted to meet them whether it be high power, economy of fuel or operation at severe angles. Write for "Industrial Applications," a very informative book to which you are welcome.

INDUSTRIAL EQUIPMENT DIVISION

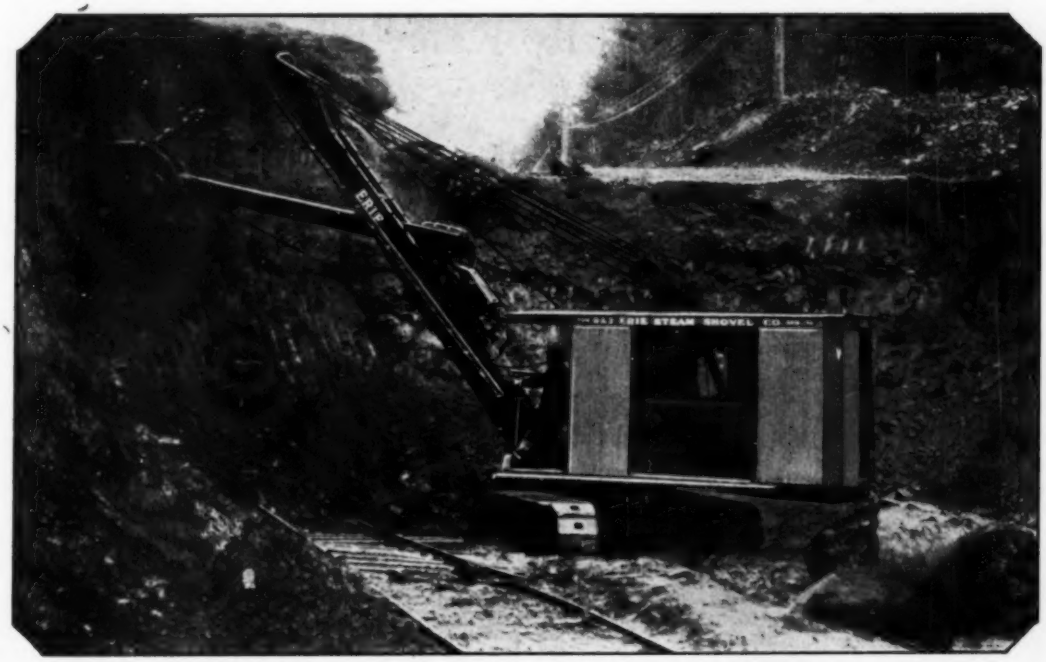
WAUKESHA MOTOR COMPANY

Waukesha Wisconsin

New York	Kansas City	Denver	Tulsa	Houston	San Francisco
Aeolian Building	*V. L. Phillips Co.*	*Wilson Machy. Co.*	*C. F. Camp Co.*	*Portable Rotary Rig Co.*	*C. A. Watts*

Exclusive Builders of Heavy Duty Gasoline Engines for Over Twenty Years

"DID NOT think a gas shovel could be made, to dig as well as steam." BUT NOW HE WRITES—



"More than pleased with Gas–|–Air ERIE"—

Read this owner's report:

"I stayed away from the gas shovel because I did not think one could be made that would dig as well as a steam machine.

"Last spring we had a job in the country on which a gas shovel was almost a necessity, and decided to try the Gas+Air ERIE and we have been more than pleased. Last month we moved 15,000 yards with this shovel and had only two trucks hauling. The material was extremely hard, but the Gas+Air ERIE dug it with ease.

"We will always be glad to speak a good word for the Gas+Air ERIE."—*B. W. Stone, Pres. Wilburn & Stone, Inc., Seattle, Wash.*

Other owners of Gas+Air ERIES, everywhere, are just as well pleased—

Let us send you some addresses of owners nearest you. Go and see these remarkable shovels, *that have given the contractor an entirely different idea of a gas shovel's output possibilities.*

Watch this gasoline shovel work with all the speed and flexibility of a steam machine. The "crowd" and "swing" are driven by direct-connected air engines that are always in gear.

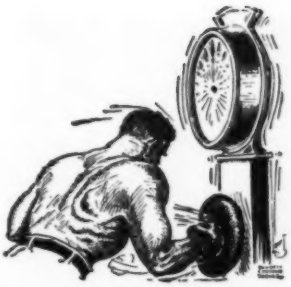
Owners tell us that, for digging ability and larger output, it has *no competition* in the gas shovel field.

ERIE STEAM SHOVEL CO., Erie, Pa., U. S. A.

Branch Offices: Boston, New York, Philadelphia, Pittsburgh, Atlanta, Chicago

GAS+AIR and Steam ERIE DREADNAUGHT

SHOVELS, CRANES, DRAGLINES, TRENCH HOES, ETC.



Built To Stand all you can give it

LORAIN 75
Reason No.
7

YOU don't need to pull your punch when you use a Lorain 75.

Give it all you've got in the way of tough work. Rip up that old pavement, gouge into the shale, juggle the huge rocks about, work it hard, push it to the limit. It's built to take it and come back for more.

One of the first needs of today in shovel or crane design is endurance. You probably know that from sad experience. All other good features of your machine can't pay profits while it is laid up for repairs.

Power, strength, endurance, was dinned into the ears of Thew engineers while designing the Lorain 75 till the outcome was even beyond our expectations.

We couldn't smash the first one in months of the most vicious tests. Owners from coast to coast will now say the same about them.

Do you want that kind of a shovel? Read how stick-to-itiveness and other features are built into this machine.

Send for the Lorain 75 bulletin.

Winning a Battle Without Firing a Shot

WHEN Williamson, Howard and Smith, contractors of Youngstown, Ohio, tackled the new Youngstown to Liverpool state road they bit off a big mouthful—and they knew it.

That's why they looked 'em all over before they picked their shovels.

Virgin territory, timbered hillsides, deep cuts through sandstone strata, here was a job for the huskiest fighting shovels procurable.

Two Lorain 75 machines were chosen. After a couple of months on the kind of digging shown above, Mr. Smith was asked how the Lorain 75s were behaving.

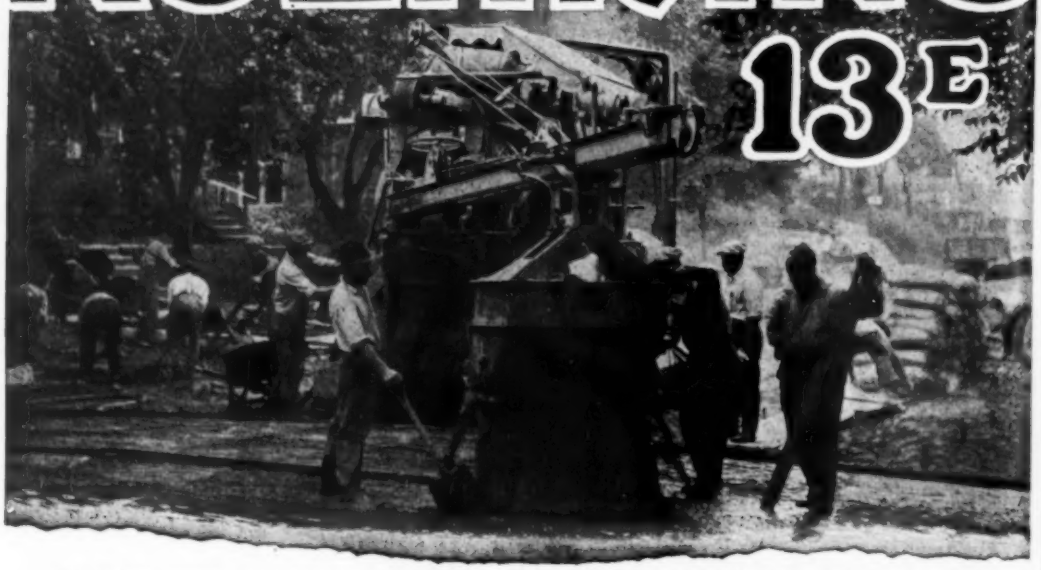
His reply was to the point. "15,000 yards a month for each shovel in that kind of stuff. No other shovel ever made could do it. The Lorain 75 is in a class by itself, that's all."

The above rock cut was made by one of the shovels alone without the help of a single blast. Is it any wonder that its owners are jubilant?

THE THEW SHOVEL COMPANY
LORAIN, OHIO

Shovels-Clamshells-Draglines
Steam, Gasoline or Electric-Mounted On
The Center Drive Truck

KOEHRING 13E



NARROW space between car track and curb! Narrow streets, highways and alleys!

There's where the narrow width of Koehring pavers will pay you extra profits, by giving you greater hauling and working room alongside.

At the same time, there is perfect, balanced distribution of weight in the Koehring, and low center of gravity, forestalling frame strains when traveling over rough, uneven ground!

Koehring automatic actions give utmost speed of operation and enable operator to maintain top speed every moment of the day. Koehring pavers are fast charging, fast discharging, fast in distributing concrete on the subgrade. They are the fast, extra yardage paving *units!*

Koehring Heavy Duty Construction is the greatest insurance against break down and delays, and the surest assurance of low maintenance and long service life.

A. G. C. Standard Sizes—in full cooperation with the Associated General Contractors standardization activities, the Koehring Company builds the full paver line according to A. G. C. ratings.

MIXER SIZES

Pavers—7-E, 13-E, 27-E. Auxiliary equipment and choice of power to suit individual needs. Complies with A. G. C. Standards.

Construction Mixers—10-S, 14-S, 21-S, 28-S. Steam, gasoline or electric power. Mounted on trucks or skids. Rubber tired wheels optional. 28-S on skids only. Complies with A. G. C. Standards.

7-S Dandie Mixer—Two or four cylinder gasoline engine. Power charging skip, or low charging hopper and platform. Rubber tired steel disc wheels or steel rimmed wheels. Complies with A. G. C. Standards.

Know the Koehring—Send for Paver Bulletin No. P 7 specifying size of paver on which you want detailed information.

KOEHRING COMPANY MILWAUKEE WISCONSIN

PAVERS, MIXERS—GASOLINE SHOVELS, CRANES AND DRAGLINES

Sales Offices and Service Warehouses in all principal cities

Foreign Department—Room 1370, 50 Church St., New York City.

Canada—Koehring Company of Canada, Ltd., 105 Front Street, East, Toronto, Ontario.

Mexico—F. S. Lapum, Cinco De Mayo 21, Mexico, D. F.

KOEHRING HEAVY DUTY

A 3225-III

The Contractor's Ever-Helpful Allies—

Cleveland Hammer Drills, Paving Breakers and Clay Diggers!

Perhaps you depend mostly on your shovels and trucks—your heavy equipment—to speed up your work. But there are times when Clevelands are indispensable. When the job strikes rock, or you are operating in shale and clay, then watch the lively Clevelands pull you out of the hole!

The Cleveland Rock Drill Co.

3734 E. 78th Street — Cleveland, Ohio

Chicago, Ill.
605 S. Dearborn St.

Detroit, Mich.
Insurance Exchange Building

New York City
30 Church St.

St. Louis, Mo.
2091 Railway Exchange Bldg.

Philadelphia, Pa.
The Bourse Bldg.

Birmingham, Ala.
403 N. 24th St., Box 2028

Pittsburgh, Pa.
922 Farmers Bank Bldg.

Negaunee, Mich.
222 Heath St.

British Representative: John MacDonald & Company, Pollokshaws, Glasgow, Scotland.

CLEVELAND ROCK DRILLS

A Sturdy ½-yard Shovel

Have you ever wished for a quicker, more economical way to complete a job like the one pictured above?

Whether it's for a crane job or for shovel work you'll be interested in this ½-yard convertible gas shovel because of its real service, low upkeep and big daily output.

In construction, this small full-circle machine combines the features you'd demand of a big shovel or crane. It's well built and will stand up. It's rugged and extremely simple — there are only 17 gears in all. And it's quicker and cheaper to move from job to job because of its light weight, reliable steering and powerful travel mechanism.

Let us make you better acquainted with this machine. Write for Booklet 126.

The Brown Hoisting Machinery Co., *Cleveland, Ohio*

Branch Offices: New York, Chicago, Pittsburgh, San Francisco, New Orleans

BROWNHOIST

GOOD MATERIAL HANDLING EQUIPMENT

Midland Trail through Shelby County, Ky., "Kyrock" on macadam, built 1924. An 18 mile stretch of "Kyrock" surface carrying an exceptional percentage of steel-tired traffic including tractors, mowing and hay tools, in addition to heavy truck and bus service. Not a crack or roll in it today.

100 percent UNIFORMITY

"Kyrock" is laid *cold*. Requires only shovels, rakes and roller and ordinary labor. Ideal for patching old sheet-asphalt, brick, block and concrete. A "Kyrock" wearing surface converts old worn roads into smooth, permanent pavements at small cost. Write today for "The Kyrock Book".

SAMPLE every square yard in every mile of "Kyrock" surface laid and it will test uniform to a fraction of one percent.

The quality and characteristics of the aggregate and asphalt are constant, the volume of asphaltic content is uniform—*guaranteed*.

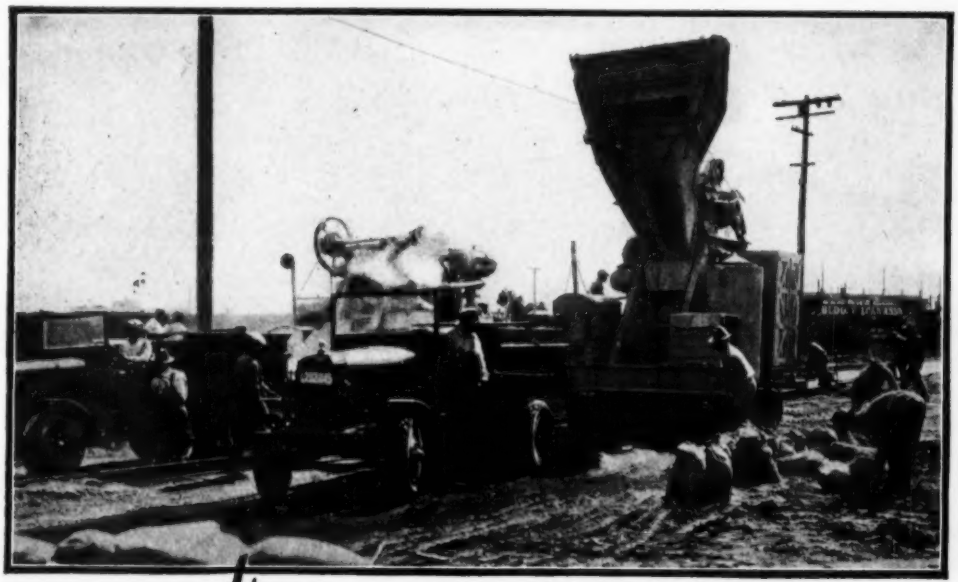
There are no lean spots to fail of bonding and ravel out, no rich spots to bleed or soften. "Kyrock" will not crack, shove, roll or wave under the extremes of climate and traffic. If the base holds, "Kyrock" stays *put—Investigate "Kyrock"*.

KENTUCKY ROCK ASPHALT CO., *Incorporated*, LOUISVILLE, KY.

Kyrock

The Perfect Pavement

KENTUCKY ROCK Kyrock ASPHALT



More yards per hour!

That's what Budd-Michelin Dual Wheels mean to the road builder

WHEN you're feeding a battery of concrete mixers you have to "scratch gravel" to keep things moving!

Getting material on the job as fast as the mixers can take it away is often a problem. And contractors are solving this problem by putting their dump-trucks on Budd-Michelin Dual Wheels and *pneumatic* tires.

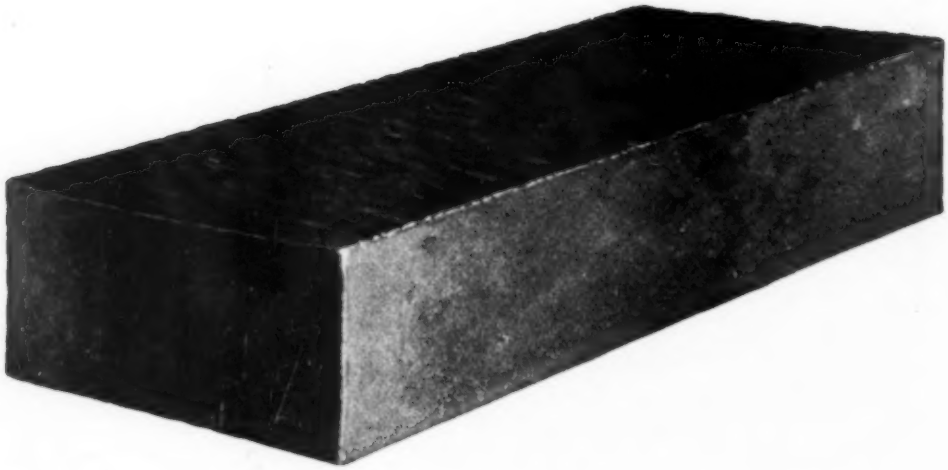
Budd-Michelin Duals enable dump trucks to hustle along at passenger-car speed. Speed that means more loads per hour. More work per day. Those dual cushions of air mean greater *traction*, too. Traction you'll be thankful for when the going's soft and slippery.

Any truck lasts longer when it rides on air—and when it rides on Budd-Michelin Duals it travels from 15,000 to 20,000 miles on a set of tires. Sixty thousand giant buses and trucks on Duals are getting that tire mileage regularly.

Ask your dealer about Budd-Michelin Duals for your next truck. He can get them on the make of truck he handles. He can tell you how you can equip your present trucks with Duals, too—or write direct to us.

BUDD
WHEEL COMPANY
Detroit

THE BUDD-MICHELIN EQUIPMENT—*two Budd-Michelin single wheels in front, two Budd-Michelin Dual Wheels in the rear (pairs of single wheels acting together as units). All wheels completely interchangeable either as units or as halves of Duals. One spare.*



Pavements of two-and-one-half-inch vitrified brick under exhaustive official test surpass all expectations

HEAVY-TRUCK traffic equal in severity to from 18 to 70 years' service on main highways failed to break down pavements laid of 2″ and 2½″ vitrified brick.

The Arlington Test, therefore, means major savings to alert communities.

It means that the first cost of vitrified brick pavements is materially reduced without sacrifice of that endurance which vitrified brick has proved and re-proved in every type of service. Let us send you complete copies of the official figures.

NATIONAL PAVING BRICK MANUFACTURERS ASSOCIATION
ENGINEERS BUILDING CLEVELAND, OHIO

PAVING BRICK Baffles the Tax Bug

VITRIFIED Brick VITRIFIED Brick VITRIFIED Brick

You Want Certain Definite Results from your Heating Equipment. Are you getting them?

These three definite things constitute the most important functions of a heater. They are what every user wants but does not always get.

Speed in Heating
Ease in handling and operating
Ability to stand the abuse of service

In Littleford heaters these three factors stand out. They will deliver hot materials in one-third the time usually required; they are the easiest heaters made to handle or operate; they stand the gaff of service for years and years with a very infrequent need of repairs. Users who have operated various types of heaters tell us it is surprising the economy made possible by the all round efficiency of our heaters.

If you are not yet acquainted with the many exclusive features of Littleford heaters, a request from you will bring full details. Just tell us the kind of work you are doing.

Contractors Special
No. 48
Capacities 300-550 Gallons.

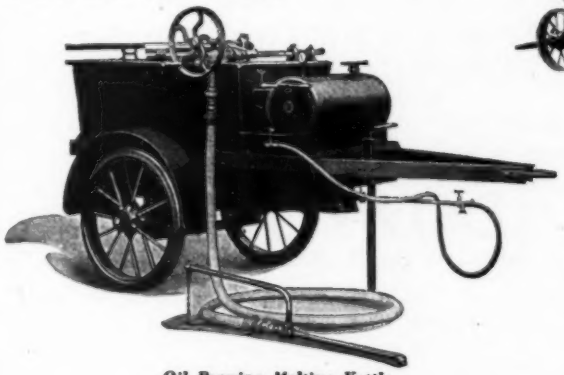
Contractors Special
No. 48
with oil burner attachment.

At the Road Show

Jan. 10th to 14th

There will be an exhibit of the complete line of Littleford Road Construction and Maintenance Equipment including The Andresen Road Repair Outfit. It will be worth your while to see at first hand the equipment you are interested in and to see the many features that only Littleford equipment possesses.

Coliseum Booth N. C. 31



Oil Burning Melting Kettle
No. 84-W
with hand spray attachment, 50-75-100 gallons capacity.

Write today for a quotation.

Rotary Sand Heater
No. 94
for Bituminous Grouting or Mastic Paving Work.

LITTLEFORD BROTHERS
449 EAST PEARL ST. CINCINNATI, OHIO

LITTLEFORD
TAR AND ASPHALT
HEATERS

CURE CONCRETE *while you mix it!*

Many road builders who previously used Dowflake as a surface curing agent are now using it added directly to the mix in the form of a solution.

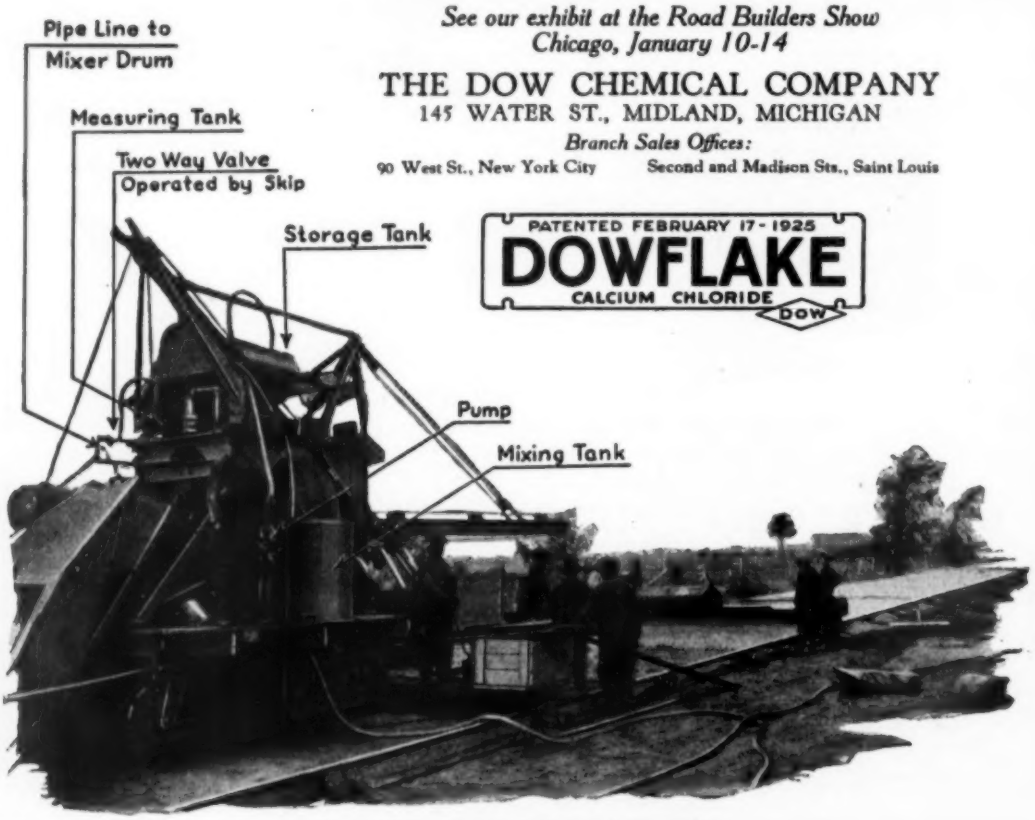
Any standard mixer can be easily equipped to permit admixture curing. The illustration shows an excellent arrangement. The Dowflake is mixed in an open-top mixing tank. From the mixing tank the solution is pumped into a storage tank. This feeds a measuring tank, which is automatically opened by the skip when it comes up. This releases the proper amount of solution which runs into the mixer drum with the cement and aggregates.

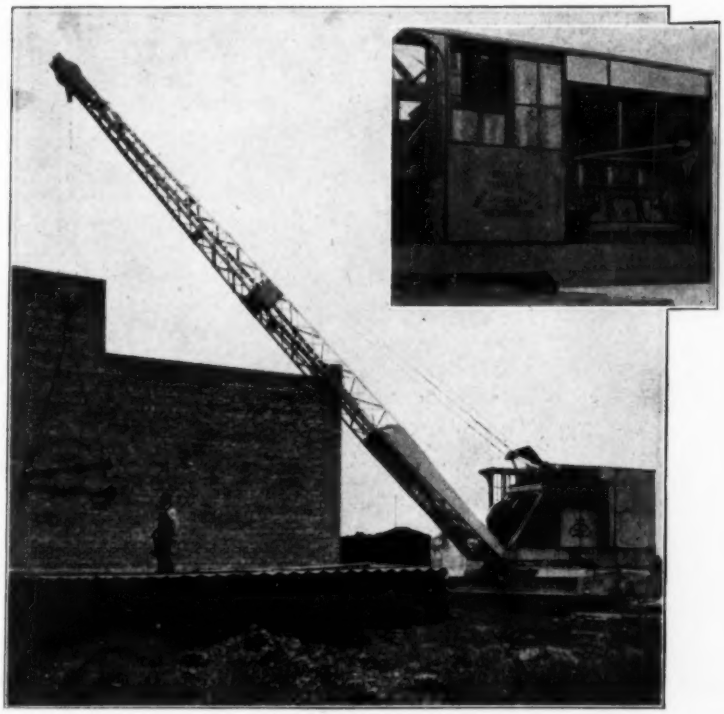
This admixture method results not only in greater economy and ease of handling, but also insures more uniform curing because the curing agent penetrates throughout the mix.

See our exhibit at the Road Builders Show
Chicago, January 10-14

THE DOW CHEMICAL COMPANY
145 WATER ST., MIDLAND, MICHIGAN

Branch Sales Offices:
90 West St., New York City Second and Madison Sts., Saint Louis





Gas tank replaces coal bunker

No more worries about coal and water; no more boilers to reflue; no need to pay a salary to an engineer and a fireman. Now all ORTON Railroad Type Cranes are available with gasoline motor operation.

Up until recent years all railroad type cranes were built with steam engines and operation was difficult when conditions for obtaining coal and water were unfavorable.

Concentration of the chemicals in even the purest water will cause scale in a boiler and it becomes necessary to reflue the boiler when the scale in the flues hinders circulation.

Today, gasoline is available everywhere and since the contractor must buy it for his trucks and mixer he can easily get an additional supply for his crane.

ORTON Gasoline Railroad Type Cranes are built in seven sizes—handling capacities from 5 to 30 tons and buckets from ½ to 2 cubic yards on 28 to 60 foot booms. Climax Trustworthy Engines are standard equipment.

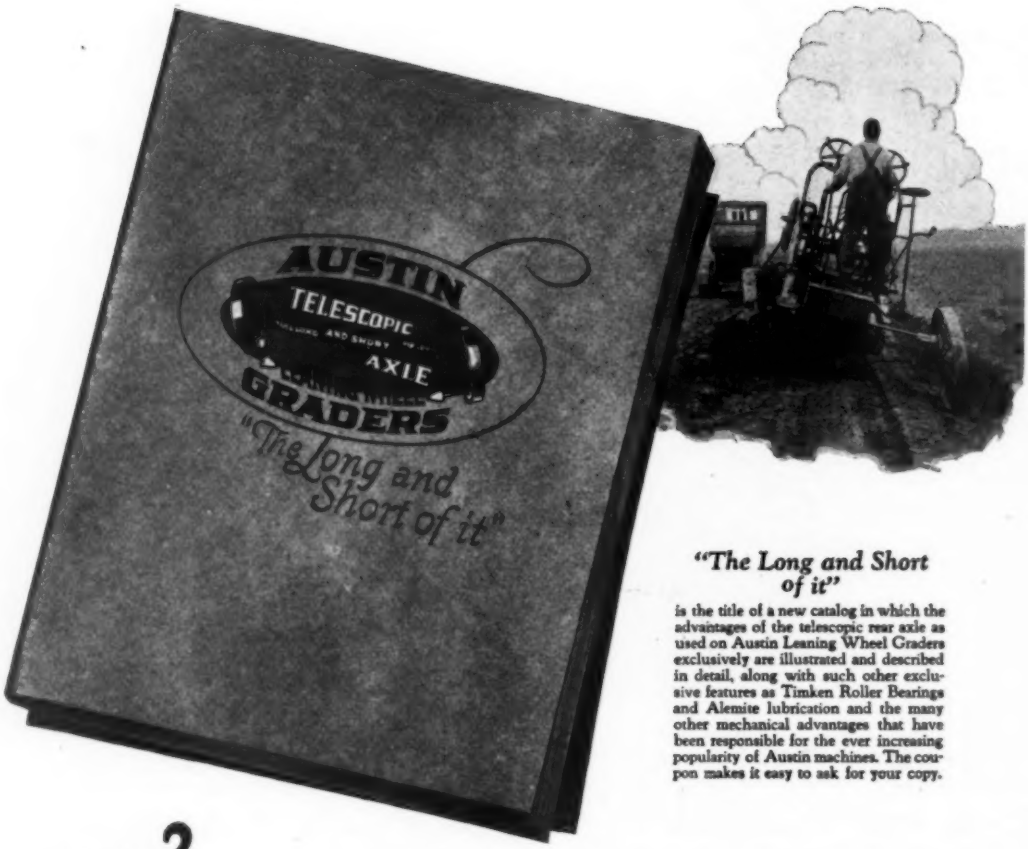
Write today for your copy of Catalog No. 37—it completely describes and illustrates ORTON Railroad Type Cranes.

ORTON CRANE & SHOVEL CO., 608 S. Dearborn St., CHICAGO, ILLINOIS
Formerly **ORTON & STEINBRENNER CO.**

Manufacturers of Gasoline, Steam and Electric Locomotive Cranes, Flexible Tread Cranes, Road Wheel Cranes, Gantry Cranes and Power Shovels.

ORTON
CRANE & SHOVEL CO.

Gasoline and Electric Truck Cranes, Rubber Tired Wheel Cranes. Clamshell Buckets, Orange Peel Buckets ½ to 5 cubic yards capacity. Coal Crushers.



"The Long and Short of it"

is the title of a new catalog in which the advantages of the telescopic rear axle as used on Austin Leaning Wheel Graders exclusively are illustrated and described in detail, along with such other exclusive features as Timken Roller Bearings and Alemite lubrication and the many other mechanical advantages that have been responsible for the ever increasing popularity of Austin machines. The coupon makes it easy to ask for your copy.

Why? is it that an Austin TELESCOPIC AXLE Leaning Wheel Grader will do more work, better work, more difficult work, and more kinds of work than any other?

Because the telescopic feature enables the operator to lengthen or shorten the rear axle at will, going places where a long axle grader could not be used at all, setting each rear wheel to run exactly where he wants it, and never being obliged to run with one wheel in the furrow as are the operators of graders with one-piece axles.

That's "*the Long and Short of it*"

Please send me a copy of your new Austin Leaning Wheel Grader Catalog, "The Long and Short of it."

.....

.....

.....

THE AUSTIN-WESTERN ROAD MACHINERY CO.

400 N. MICHIGAN AVE., CHICAGO, ILL., U.S.A.

Branches in all Principal Cities

BREAKING TRAILS

WESTERN Dump Wagons are playing a big part in opening up one of the old mountain trails of the Ozarks. J. J. Sparks of Kirkwood, Missouri, bought a car load of Western 1½-yard Dump Wagons for use in Wayne County road construction for the State. It was not an easy job, as the pictures will prove, but Western equipment is keeping up its usual reputation for always giving dependable service.

EASY draft, rugged construction, unusually short-coupled, and a special three-up hitch of our own design are a few of the reasons why contractors everywhere prefer Westerns. No matter how hard the job you can depend on Westerns to pull you out of a hole.

Use Westerns for your next tough job

Send for our illustrated folder on Dump Wagons

Western Wheeled Scraper Co.

Founded 1877

Builders of Dump Cars and Earth and Stone Handling Equipment

AURORA, ILLINOIS

Made To Order For Every Road, Bridge and Culvert

Wacker Drive, Chicago
Reinforced by Corrugated Bars

NO matter how small or how large the job—wherever reinforced concrete is used—in roads, bridges or culverts—Corrugated Bars can save time and money for contractors. Kalman Engineers co-operate to determine the exact requirements for every job, regardless of the size.

At Kalman warehouses *Corrugated Bars* are cut to length and bent as specified. They are bundled for easy handling, tagged for ready identification, and shipped at the designated time.

On arrival at the construction site, *Corrugated Bars* when ordered bent, are ready for quick and easy setting. There is no bending or cutting to be done—and no steel wasted. The tag on each bundle shows where it belongs. Setting time is cut to the minimum.

You'll need steel for your next culvert or bridge job. Why not have it made to order? You will save both time and money. Just send your blue prints and we will give you complete information and recommendations.

Remember—no job is too small or too large for the advantageous use of *Corrugated Bars*.

KALMAN STEEL COMPANY, 1458 Wrigley Bldg., Chicago

KALMAN STEEL

Plants or Offices at

Chicago New York Cleveland Buffalo Detroit Boston Baltimore Pittsburgh Syracuse Milwaukee Philadelphia St. Louis St. Paul KansasCity Columbus Atlanta Dayton Minneapolis Youngstown

Adams ADJUSTABLE LEANING WHEEL Graders

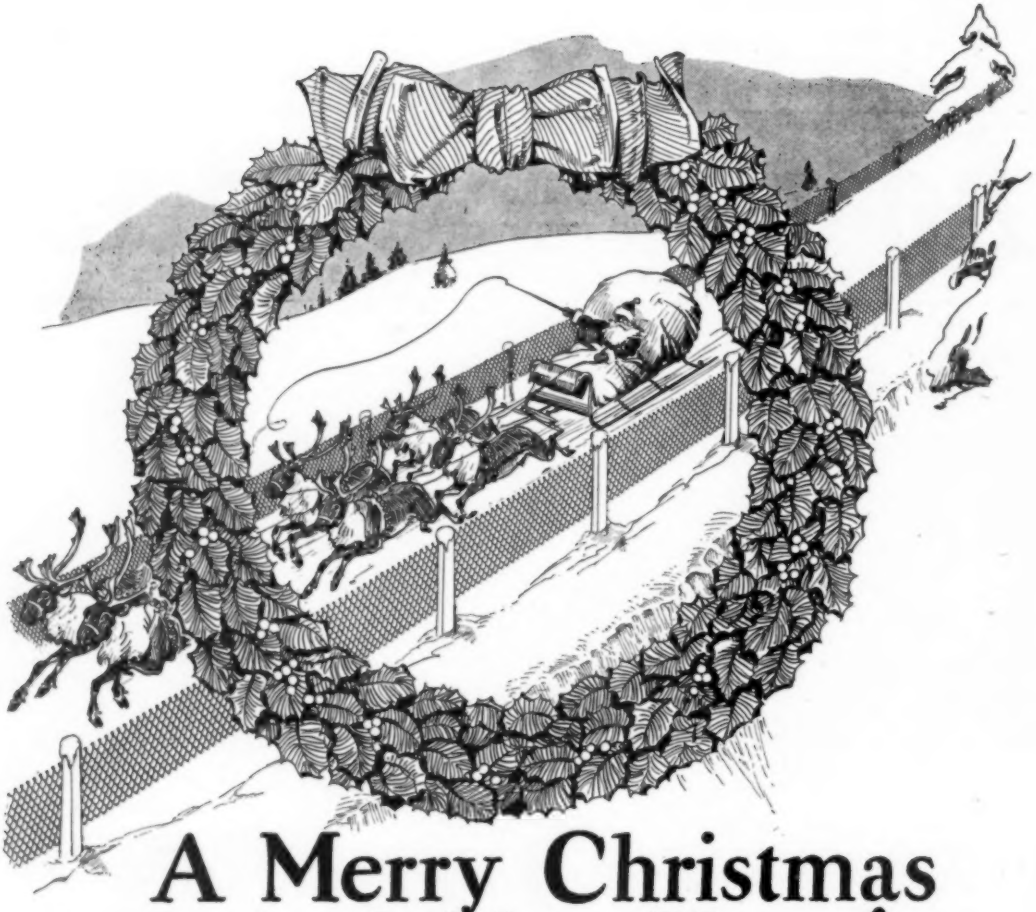
"The Original - A Proved Success Since 1885"

The adjustable leaning wheel feature of Adams Graders is simplicity itself. It simply applies the common sense principle illustrated by the man and the wheelbarrow in the Adams trademark, and leans the weight of the grader against the load it is moving. That is why Adams Graders do not skid, are easier to control and move more dirt with less power than other graders.

J. D. ADAMS & CO., Indianapolis, Ind.

Minneapolis, Dallas, Kansas City, Mo., Spokane
Harrisburg, Pa., Memphis

Trade Mark Reg. U. S. Pat. Off.



A Merry Christmas and a *safe* New Year!

PAGE STEEL *and* WIRE COMPANY
BRIDGEPORT, CONNECTICUT
District Offices:
Chicago New York Pittsburgh San Francisco
An Associate Company of the American Chain Company, Inc.
Bridgeport, Connecticut

PAGE STEEL AND WIRE QUALITY PRODUCTS

TRADE MARK
America's first wire fence-1883

You will find a warm welcome and a very interesting exhibit of Hi-Way Guard at the Road Show to be held January 10-14th at the Coliseum in Chicago. Be sure and visit Spaces NB 11 and 12 in the balcony.

ACCO
AN ASSOCIATE COMPANY OF AMERICAN CHAIN COMPANY, Inc.
in business for your safety

PAGE HI-WAY GUARD

[PATENT PENDING]

"The Lifeline of the Highway"

Another RUSSELL MOTOR PATROL

No. 4 Caterpillar Two-Ton Tractor for Power

This motorized Grader is built for heavy maintenance work on gravel or earth roadways. It is capable of working in loose or sandy soil where wheel type tractors could not used.

The operator's station is at rear of machine where he has an unobstructed view of the road ahead as well as that of the blade. The steering machanism is similar to the wheel type motor graders. The unite is very easily handled, has plenty of power, and the entire outfit is most sturdily built.

No. 3—Russell Motor Patrol
Has McCormick-Deering 10—20 Tractor For Power

No. 2—Russell Motor Patrol
Has Fordson Tractor For Power

The many improved features found on these machines insure economy, service, and lower up-keep cost.

Each model equipped with scarifier and may be adjusted to work with blade or separately as desired.

For many years Russell engineers have continually tried out new designs, keeping always in mind one purpose; to build machinery that will make road-building more satisfactory and economical. There is a fundamental reason for every feature of Russell design, and as better designs are perfected they will be embodied in Russell dependable equipment.

The complete Russell Line for Road construction, road maintenance and road repairing includes—

10 Sizes Road Machines—2 Sizes Elevating Graders—

Maintenance Patrol Machines for both Motor and Horse Power, Scarifiers, Road Drags and Wheel Scrapers, Drag Lines, Gravel Screening Crushing, and Loading Equipment, Steel Beam Bridges, etc.

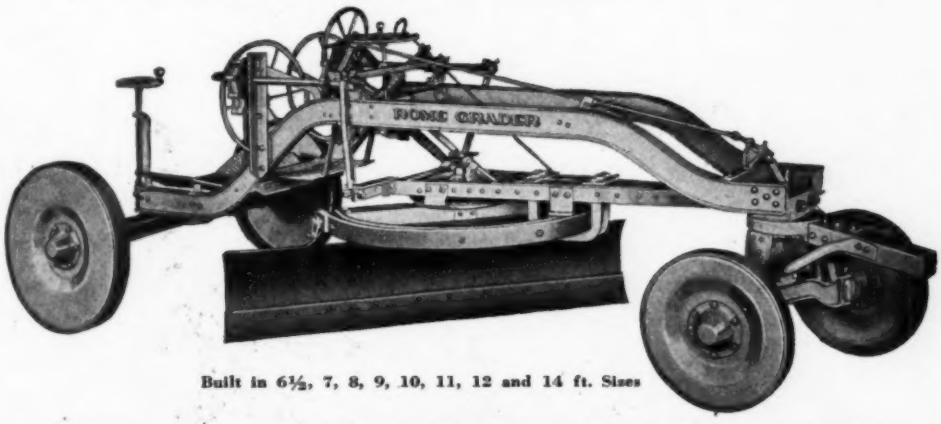
Our catalog of special interest to all road builders—sent free and postpaid.

RUSSELL GRADER MFG. COMPANY
Factory and General Offices
MINNEAPOLIS, MINN.

Affiliated plants—Cicero, Ill., North Kansas Cty, Mo., Memphis, Tenn., Dallas, Tex.
Representatives in all principal cities.

THE GRADER OF TODAY

THE "ROME" HIGH LIFT GRADER is a new and interesting development and a decided advance in the construction of this type of road building machinery. It has EXCLUSIVE FEATURES, patents on some of which have already been allowed.



Built in 6½, 7, 8, 9, 10, 11, 12 and 14 ft. Sizes

HIGH LIFT "ROME" GRADERS

are designed so that the mould-board can be adjusted to an angle to obtain either a one to one or one to one and one-half slope, thus making a practical bank sloper without additional cost or attachments. First cost, is now the only consideration, extra parts have to be transported from place to place and are often at the other side of the county when needed. With the ROME Grader it is not necessary for the operator to leave his platform—In a very short space of time he can set the machine in a sloping position and can do this additional work quickly and efficiently.

Frame Made from heavy structural steel I-Beams, rigid and strong and yet flexible enough to adjust itself to road irregularities. Adequate in weight and perfectly balanced.

Steering Gear is the Rome Patented Knuckle and Spindle type, the same as used on automobiles and motor trucks. It is specially designed so the grader can also be guided with the pole.

Pole The combination steering, horse and tractor pole is made from pressed steel and so constructed that it can be telescoped, making a stub tongue or pole for engine use.

Wheels This is a new departure, disc wheels made from ¼" steel boiler plate, and properly concaved for strength. These wheels will have special long roller bearings and the hub capped at both inner and outer ends to prevent dust and dirt from getting into the spindles.

Axles Front axle cast steel, rear axle high carbon alloy steel, the spindles machined from the solid on each end. The rear axle is pivoted, which adds greatly to the efficiency of a grader and permits of road operations that would be impossible or difficult without such a device.

Circle and Knees Made from high grade carbon steel in double sections bolted together with spacers. A strong and rigid construction. Holds the mould-board steady and leaves no waves in the finished work.

Mould-Board is of carbon steel made rigid by heavy reinforced angle iron bolted to the back. Cutting edge is from high carbon steel ground and polished and with a beveled cutting edge. The mould-board is curved to get just the right effect in rolling the earth away.

Gears All gears have cut teeth and are enclosed in oil-tight gear cases running in a bath of oil. Worm screws are hammered forgings with cut teeth.

Lubrication Alemite system throughout.

These graders are built in our locomotive department by skilled mechanics and with facilities fully adequate for producing first class machines. See our exhibit at the Road Show, The Coliseum, Chicago, January 10 to 14th, 1927.

Rome Graders afford a real opportunity for live and energetic distributors. Territory is rapidly being taken up, but there is still some available.

Write us for further information, prices, etc. Address—

ROME MANUFACTURING COMPANY

ROME, NEW YORK **Dept. 4.** **U. S. A.**

When you're "20 Miles from Nowhere" on a "He" job—you'll surely need

WILLIAMSPORT WIRE ROPE

TELFAX TAPE MARKED

Because: You'll want to *know* the tensile strength of the wire rope you're using.

Williamsport—alone—gives you this proof.

That's why "Monighan Walkers" are equipped with Williamsport Wire Rope. Able Engineers declare that taking chances on any part of their equipment, particularly on isolated jobs, is poor business efficiency, to say the least. They just won't do it. Others must go through the bitter experience of a tie up or accident to be convinced.

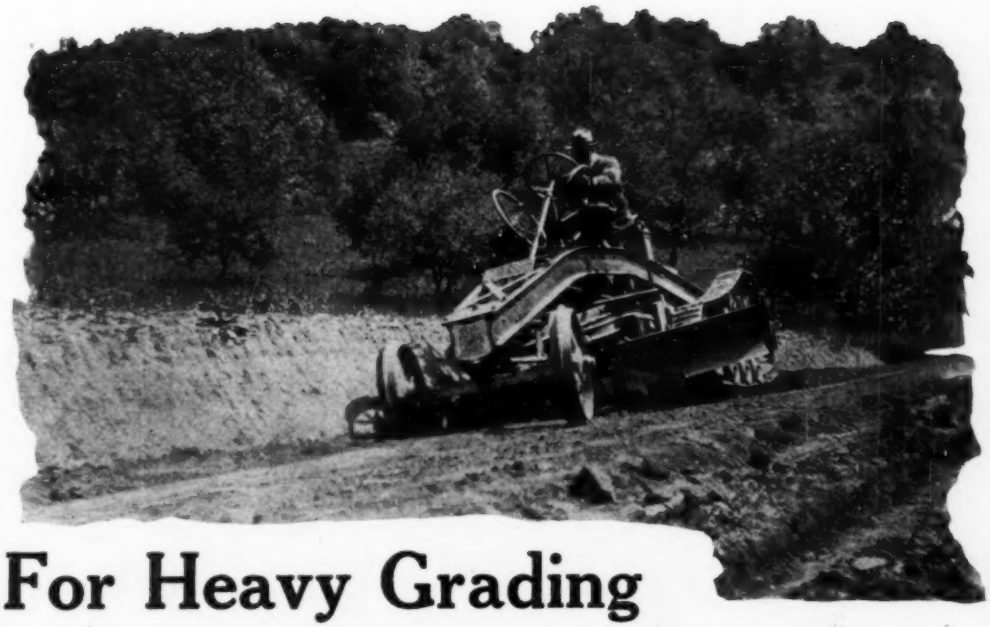
Most manufacturers of good machinery on which Wire Rope is a part of the equipment use Williamsport for your protection.

Your safety is paramount to a slight difference in cost in the minds of these manufacturers.

WILLIAMSPORT WIRE ROPE COMPANY

Main Office and Works
Williamsport, Penna.

Gen'l Sales Offices
Peoples Gas Bldg., Chicago



For Heavy Grading

Where real scarifying and deep ditching must be done, the Trackson Full-Crawler with the one-man power Fordson grader, is the most practical equipment.

Its great track area of 1,100 square inches takes the grader through the hardest of soil or the muddiest ditches without any trouble.

Its all steel construction gives it the sturdiness to stand up and keep going under severe punishment.

Its flexibility of power and speed gives it a range for every job; slow for heavy, fast for light work.

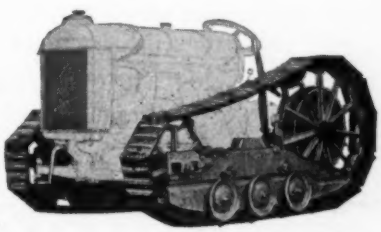
The low purchase price and economical operation mean a substantial saving over any other equipment adaptable to this work.

Get our illustrated booklet which shows where and how you can save money by using this equipment. Send for it today.

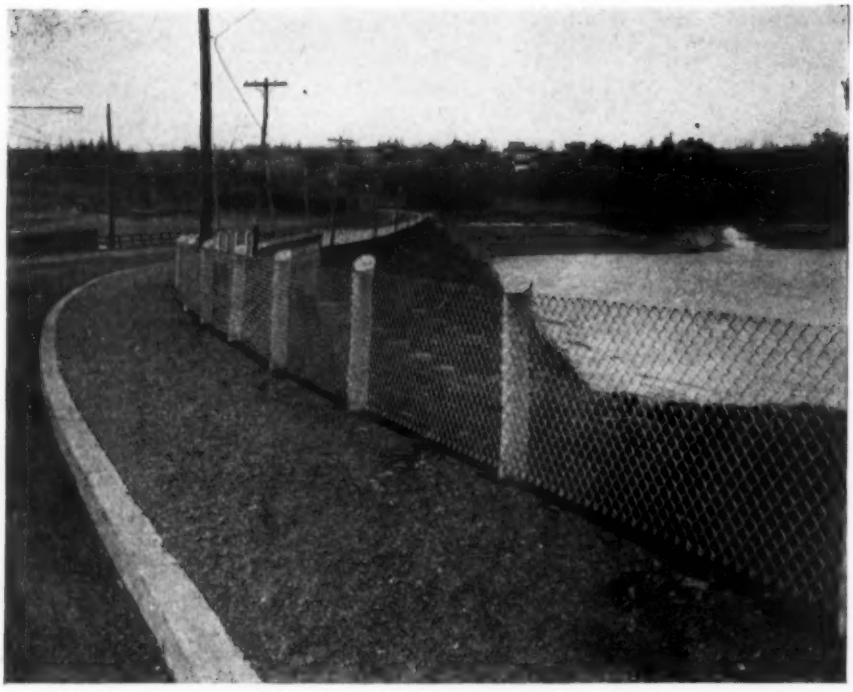
The Full-Crawler Co.

Dept. of Geo. H. Smith Steel Casting Co.

501 Clinton St. Milwaukee, Wis.



Trackson
Full-Crawler for Fordsons



FOR ECONOMY and BETTER PROTECTION

Economy and Protection—Wickwire Spencer Chain Link Highway Guard provides the maximum of both.

Less Labor is required for erection, less attention for upkeep. No painting required.

Made of copper bearing steel, hot galvanized *after* weaving. The extra heavy coating of pure zinc thus obtained is an excellent protection against rust and insures long life.

They stretch under impact, thus acting as a bumper to minimize damage to automobiles and the occupants.

Furnished in standard specifications of 2″ mesh, No. 6 (W & M) gage, 24″ wide.

Another economical protection for roads is the Extra Galvanized Strand Highway Guard. This is heavily galvanized and is furnished in reels of convenient length to assist quick installation.

For further information write to:

WICKWIRE SPENCER STEEL COMPANY

General Offices: 41 East Forty-second Street, New York
Western Sales Office: 208 South LaSalle Street, Chicago

Worcester Buffalo Cleveland Detroit
San Francisco Los Angeles Seattle

WICKWIRE SPENCER *PRODUCTS*

ARE You Ready For This?

"Fair weather" roads, that go out of use with the first heavy snowfall, can be made "all year" roads with the H-P "One Man" Grader.

One man alone can handle the H-P Grader in the heaviest snow. H-P Rigid Rail Tracks, equipped with Ice Lugs for winter use. "CRAWLERIZE" the tractor and give it a tremendous pulling power that will send it through the biggest drifts and over glassy ice.

The H-P "One Man" Grader is easy to turn, and will not interfere with traffic while at work.

The H-P Cab for winter use keeps the operator snug from the weather.

Write for our folder "When Snow Flies" for data on snow removal.

Hadfield-Penfield Steel Co.
BUCYRUS **OHIO**

H-P "Crawlerizers"
H-P Rollers

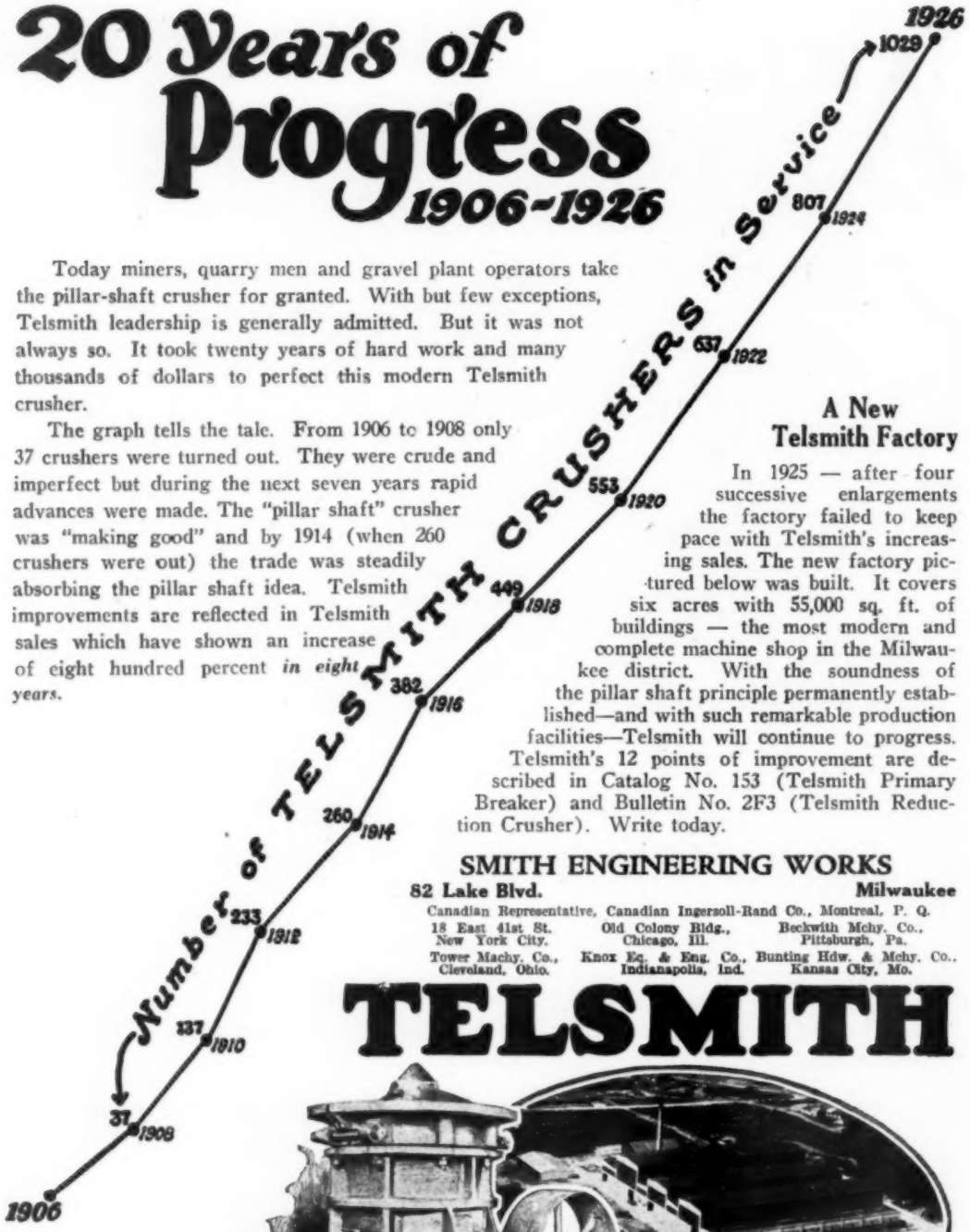
H-P Du-Pat Dump Scrapers

Remember that H-P "One Man" Graders are year-around machines. They are used in grading, ditching, scraping, rooting, scarifying, scooping, and patrol work.

20 Years of Progress 1906-1926

Today miners, quarry men and gravel plant operators take the pillar-shaft crusher for granted. With but few exceptions, Telsmith leadership is generally admitted. But it was not always so. It took twenty years of hard work and many thousands of dollars to perfect this modern Telsmith crusher.

The graph tells the tale. From 1906 to 1908 only 37 crushers were turned out. They were crude and imperfect but during the next seven years rapid advances were made. The "pillar shaft" crusher was "making good" and by 1914 (when 260 crushers were out) the trade was steadily absorbing the pillar shaft idea. Telsmith improvements are reflected in Telsmith sales which have shown an increase of eight hundred percent *in eight years.*



A New Telsmith Factory

In 1925 — after four successive enlargements the factory failed to keep pace with Telsmith's increasing sales. The new factory pictured below was built. It covers six acres with 55,000 sq. ft. of buildings — the most modern and complete machine shop in the Milwaukee district. With the soundness of the pillar shaft principle permanently established—and with such remarkable production facilities—Telsmith will continue to progress. Telsmith's 12 points of improvement are described in Catalog No. 153 (Telsmith Primary Breaker) and Bulletin No. 2F3 (Telsmith Reduction Crusher). Write today.

SMITH ENGINEERING WORKS

82 Lake Blvd. **Milwaukee**

Canadian Representative, Canadian Ingersoll-Rand Co., Montreal, P. Q.

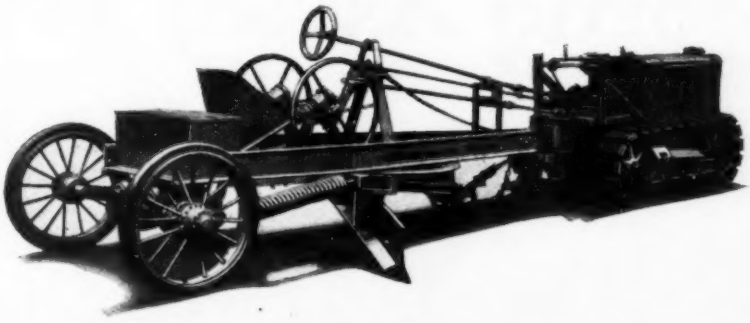
18 East 41st St. New York City. | Old Colony Bldg., Chicago, Ill. | Beckwith Mchy. Co., Pittsburgh, Pa.

Tower Machy. Co., Cleveland, Ohio. | Knox Eq. & Eng. Co., Indianapolis, Ind. | Bunting Hdw. & Mchy. Co., Kansas City, Mo.

TELSMITH

Aeroplane View of new Telsmith Plant

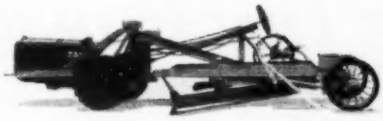
P. B. No. 10



Now You Can Have Shawnee Performance

with

"CATERPILLER" I. H. C. 10-20 or Fordson Power



The Shawnee Fordson Power Grader

The Shawnee International 10-20 Power Grader. Also furnished in quick detachable type

The justly famous Shawnee Power Grader is now available in unit types with Fordson and International 10-20 power, and in quick detachable types with hookups for "Caterpillar" 2-Ton and International 10-20.

Quality construction and superior performance form the basis on which Shawnee reputation has been established. One look at the heavy Shawnee I Beam frame, the massive crank rear axle, with cut gears as closely machined and finished as those in any well built automobile, the ingenious, perfectly engineered hookup and steering control—and the fact that the Shawnee is built to outlast and outperform any other road maintenance and patrol machine is perfectly evident.

Shawnee construction necessitates a higher first cost—but to the purchaser of graders who is interested in accuracy, dependability, low upkeep and low cost per mile, and in a maintenance machine that continues on the job year after year—first cost is nothing—final cost everything. And we believe the Shawnee, per year and mile of service, is the cheapest power grader on the market.

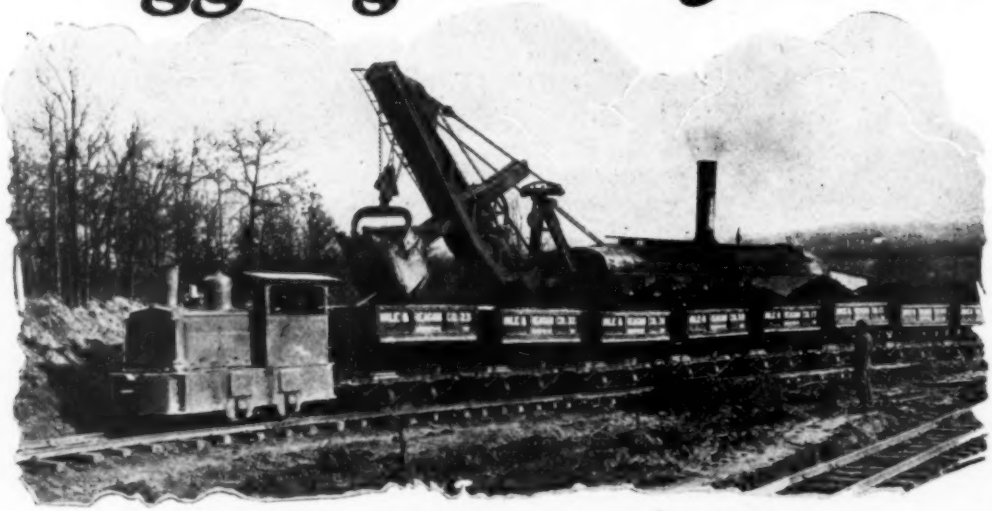
All the Shawnee Power Graders will be shown at the Road Show, Jan. 10-14, in space NC 10. It will pay you to see them.

SHAW ENOCHS TRACTOR CO.

2416 University Ave., S. E.

Minneapolis, Minnesota

Tugging Away Tons



Beaver Delivers the Power!

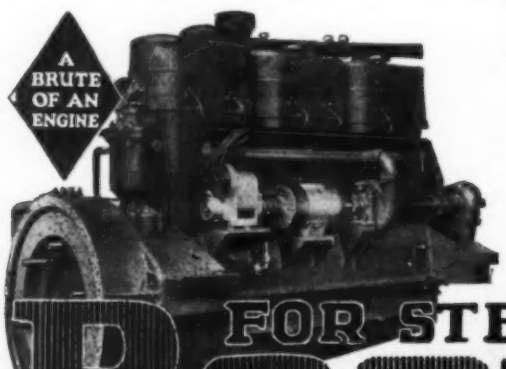
Preparing the grade—tugging away tons after tons of packed earth and rock—this is the assignment of Whitcomb Locomotives owned by Yale & Reagan Co. at work at Harrisburg, Ill. They are making way for the I. C. R. R.

It logically follows that equipment chosen for this mammoth grading job must be *fit for heavy service*—equal to the work—for profit is weighed against the performance. And the performance is dependent upon its *power—Beaver power.*

You invariably find the Beaver on work of this kind. Simply because it is designed for heavy duty—it is responsive and reliable—it runs smoothly and economically and does so consistently.

Beaver Engines are of the valve-in-the-head design which gets the maximum power out of every explosion; "oversize" working parts and remarkably vibrationless operation assure longer life; force-feed lubrication is fool-proof and trustworthy and its gas consumption is unusually low.

Write for Industrial Bulletin which thoroughly describes Beaver Engines in detail.



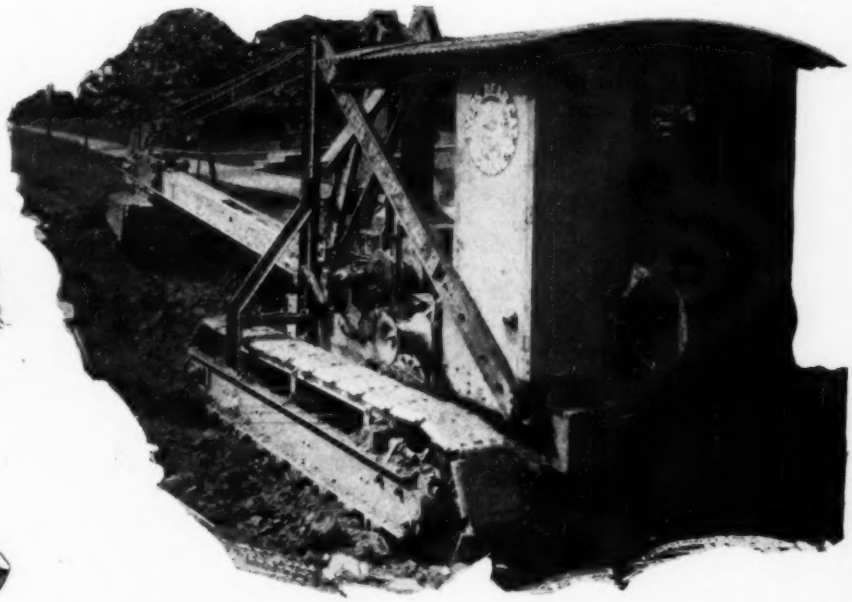
BEAVER MFG. CO.

34 25th St., Milwaukee, Wis.

FOR STEADY SERVICE

Beaver

You're buying PERFORMANCE, *not claims!*



WHAT you as a buyer of machinery are concerned about is the most dirt-moving ability per day per dollar

And the man whose word you are most likely to take for that is neither the manufacturer nor the salesman, but the fellow who owns one of the machines in question.

That's why so many of the Bear Cat ads are simple statements of Bear Cat owners. Here's one from Frank M. Bullis, Corvallis, Ore., who has a Bear Cat Ditcher and Skimmer with the combination boom:

"I like the Bear Cat first class. No other can move the dirt per hour that is not clear above its class. We are now loading on wagons out of a 5 to 12 foot cut on our highway job, with the ½ yard skimmer bucket, from 400 to 500 yards in 8 hours."

Do you want to hear what a lot of other owners say about "the all-purpose one-man crane"? Just send the coupon.

THE BYERS MACHINE CO., Ravenna, Ohio

Builders also of Byers Truckrane

Sales and Service Throughout the Country

The Byers Machine Co., Ravenna, O.
Gentlemen:—
Please send booklet with statements of Bear Cat owners and complete descriptive Catalog. The type of work I am particularly interested in is .....
.....
Name .....
Address .....
Town .....
State .....
R&S 12-26

BYERS BEAR CAT

Loading at Low Cost with Buda Power

The Buda-equipped Link Belt Crawler-Loader has speed, power and stamina. It is designed and built to lower the costs of loading and hauling.

Successfully handling 350 cubic yards of building material each 9-hour day, a representative Link Belt user reports:

The operating cost, all items included, amounted to $17.93 a day.
Due to more rapid loading, the saving in truck time was $39.78 per day.
The total saving in loading and hauling costs was $104.53 per day.

Savings such as these are typical of the economical performance of Buda-powered industrial machines. Buda engines are helping to lower the operating and maintenance costs in over 30 big industrial lines. Sizes range from 20 to 87 horsepower. Write for complete specifications.

THE BUDA COMPANY, HARVEY CHICAGO SUBURB ILLINOIS
ESTABLISHED 1881

BUDA
INDUSTRIAL
POWER

Detroit needed a many purpose crane

A full-revolving crane, designed for the greatest variety of service—

A crane of maximum stability with minimum road weight.

And of established reputation for lowest operating and maintenance cost—

A Bay City type "R" Motor Truck Crane met every demand

(And so well did a BAY CITY CRANE "fill the bill" that Detroit has just ordered another.)

Used with a bucket, that crane handles an average of 9 to 11 cars of gravel in 10 hours. (Reports show that BAY CITY CRANES frequently unload 13 cars in a day). For the hoisting of water pipe, structural steel, stone or other heavy material, the control and accuracy of the BAY CITY CRANE are well known.

Then there's its speed in getting from job to job—its efficient design, made possible by a lengthy investigation that covered every portable crane need—and its unusually strong construction that makes hard service easy on the crane and its long life a certainty.

When writing for the BAY CITY CRANE folder please mention the work you do.

Bay City Foundry & Machine Co.

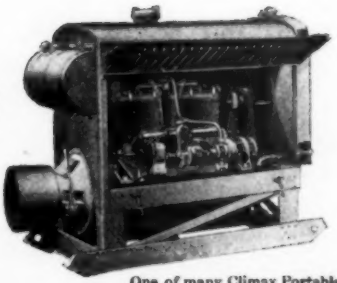
Bay City, Mich.

Now

It's Easy to Order CLIMAX

Trade Mark Reg. U.S. Pat. Off.

—Belted Power Units
—Direct-Connected Generators
—Direct-Connected Pumps
—Power for Fire Pumps



One of many Climax Portable and Stationary Power Units, ranging in Power from 35 to 140 H. P., for every power requirement.

See how easy

1st

Write for

Bulletin E on Belted Units.

Bulletin F on Direct-Connected Generators.

Bulletin G on Direct-Connected Pumps.

Bulletin I on Climax Engines listed as Standard by Underwriters' Laboratories for Fire Pumps.

2nd

Order the Unit you need by code, sending certified belt power of unit to be driven.

3rd

Tell us whether you will supply the *driven* Unit to be driven, in which case send us certified blue print so we can machine base of Climax Unit and bore coupling to fit your unit;

or

Authorize us to furnish complete driven Unit and it will come forward installed on base.

No further writing—No further worry

CLIMAX ENGINEERING CO., 65 W. 18th Ave., Clinton, Iowa

See any Pump or Generator Company or their Agents or any of the authorized Climax Dealers named below.

Eastern Branch: 30 E. 42nd St., New York, N. Y.
Cleveland Branch: 657 Leader Bldg., Cleveland, Ohio
Chicago Branch: 2007 Harris Trust Bldg., Chicago, Ill.
El Paso, Texas: Sheehan & Co., 1516 Bassett Ave.
New Orleans, La.: Woodward, Wight & Co. 451 Howard St.
Southwestern Branch: P. J. Dasey, Hotel Wells, Tulsa, Okla.
Los Angeles, Calif.: Coast Machinery Corp., 464-66 E. 3rd St.
San Francisco, Calif.: Coast Machinery Corp., 829 Folsom St.
Birmingham, Ala.: Keiser-Geismer Engr. Co., 1308-9 American Trust Bldg.
Boston, Mass.: Rapp-Huckins, 59 Haverhill St.
Denver, Colo.: The Hendrie & Bolthoff Mfg. & Supply Co., 1621-39 17th St.
Jackson, Miss.: Anderson Sales & Distributing Co.
Jacksonville, Fla.: Construction Equipment Co., 437 East Bay St.
Madison, Wis.: Wisconsin Machine & Foundry Co.
Minneapolis, Minn.: Wm. H. Ziegler Co., 619 Washington Ave. S.
Portland, Ore.: J. L. Latture Equipment Co., 354 Belmont St.
St. Louis, Mo.: Tulley Equipment Co., 2339 Pine Street
Omaha, Nebr.: Interstate Machinery & Supply Co.
Indianapolis, Ind.: Carl Dunning Supply Co., 204 W. Maryland St.
Montreal, Que., Can.: Edward C. Dingman, 1005 Keefer Bldg.

Visit our Exhibit at the National Road Show, Chicago, Jan. 10-14, 1927, Booths W-11 and W-12.

Bucyrus Headquarters at the Road Show, New Coliseum Balcony—Booth No. 75.

A Shovel That Is a Shovel

The New Bucyrus 31-B is a Contractor's Real 1-yard All-around Digging Tool

On grade—in the hole—against the bank

The New Bucyrus 31-B is a Real 1-yard shovel. It is really built to handle a full 1-yard dipper.

It gets in more minutes of actual digging per day than ordinary shovels.

The two-part hoist raises and lowers the dipper much more efficiently and faster than the usual three-part hoist. And the new 31-B is powered to crowd, hoist, and swing in the shortest possible time.

The twisting strains common to the single type dipper stick in all kinds of digging, especially mixed rock and earth, are eliminated. The outside dipper handles crowd the dipper squarely into the bank.

The 31-B digs a yard at every pass. There is no bail and no heavy bail lugs to obstruct the mouth of the dipper. And the padlock is pin connected to the steel cast dipper back so that even the larger rocks can be scooped up.

The 31-B can dig to grade on road work — can maneuver about a pit and load high on the bank—can dig squarely into a bank, all with the same assurance of consistently greater yardages.

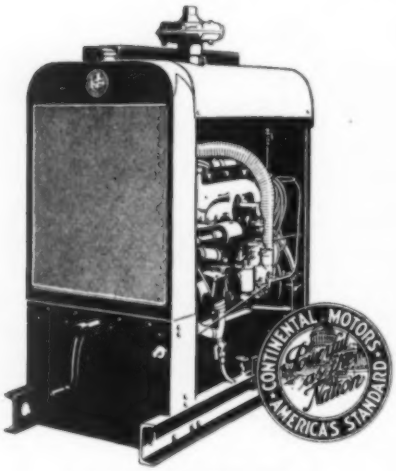
There are any number of added advantages that make the New Bucyrus 31-B a Real 1-yard digging outfit for the Contractors. If you would like to see and read about them— write for Bulletin C-311.

Bucyrus Company, South Milwaukee, Wisconsin

BUCYRUS

NEW YORK CHICAGO BIRMINGHAM SAN FRANCISCO PITTSBURGH TOKYO LONDON

Power for a ~ thousand uses



Dependable Power For Every Purpose

Where industry functions, power has a place.

Wherever gasoline power is used, Continental Motors are outstanding for dependability, economy and proper design.

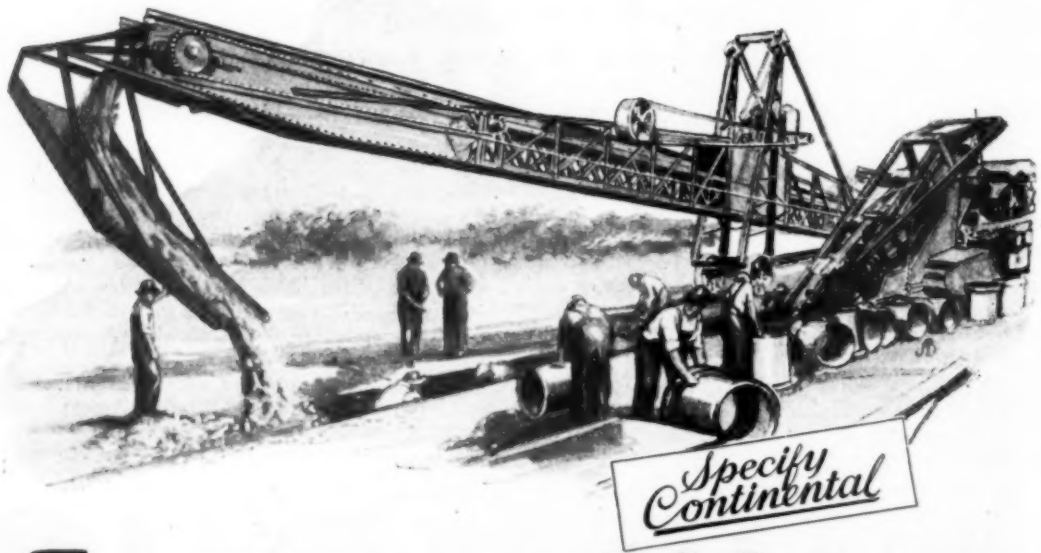
Road building, lumbering, plant construction, railroading and material handling—these are among the few of their thousands of uses.

26 years of specialized experience is one reason for Continental's present leadership in the industrial power field.

CONTINENTAL MOTORS CORPORATION

Offices: Detroit, Mich., U. S. A. *Factories:* Detroit and Muskegon

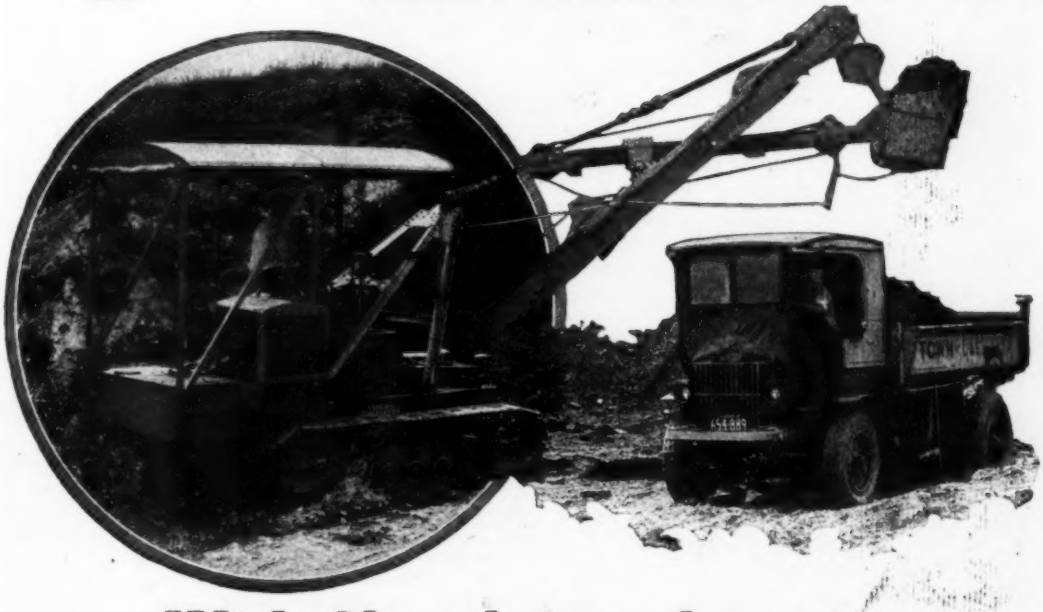
The Largest Exclusive Motor Manufacturer in the World



Continental Motors

THE INSLEY EXCAVATOR

for SHOVEL · DITCHER · CRANE
SKIMMER AND DRAGLINE WORK



With Shovel Attachments

WORKING in a sand or gravel bank handling material from stock pile to truck, working in a borrow pit, or grading a street or road is ideal work for an Insley Shovel. It will handle from 200 to 450 cubic yards a day with great efficiency and at a low cost by virtue of its speed of operation, and will dig any kind of material satisfactorily. Its first cost is low, and it is strictly a one-man machine.

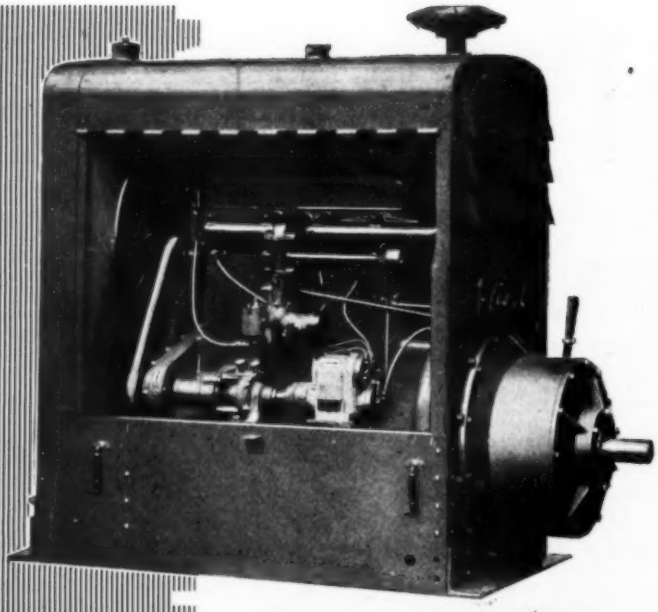
Ease of operation must accompany speed of operation if the best results are to be obtained. The Insley Shovel is easy to handle, so that the operator can get full hourly capacity without undue fatigue. This is worth money to the owner.

Write for Catalogue No. 49 and arrange to inspect one of these machines.

INSLEY
CONCRETE PLACING EQUIPMENT
STEEL DERRICKS
BUCKETS AND CARS
EXCAVATING EQUIPMENT
487

Insley Manufacturing Company · Indianapolis

Engineers and Manufacturers



Better POWER and A longer Run

Plus "More Power Per Cubic Inch," Wisconsin Motors have the additional advantage of a long service life that keeps maintenance cost far below ordinary motors.

Wisconsin has worked toward this end year by year, concentrating on the efficient overhead valve principle, developing and refining, bettering the details of accessibility, perfecting assembly and workmanship standards.

Each Wisconsin Motor, Six or Four, 20-horse or 120, will deliver, consistently, more work per unit of fuel and oil, more service between overhauls, with less lay-up time.

For trucks, tractors, industrial machinery and busses, Wisconsin offers the lowest cost POWER available. Let us prove this—in terms of your own power needs.

MORE POWER *per* **CUBIC INCH**

Wisconsin Motor Mfg. Company
Milwaukee, Wisconsin

Wisconsin Motors are manufactured in a full line of Sixes and Fours, with power range from 20 to 120 H.P., for trucks, busses, tractors and construction machinery.

Wisconsin
CONSISTENT

Performance!

See the

Speeder

at the

Chicago Road Show
January 10-14

You've heard a lot about the Speeder; maybe you have not yet had an opportunity to look one over.

The Speeder will be at the Chicago Show for your inspection. Come and see us — get acquainted — learn what the Speeder is doing on work similar to yours.

Today's buyers of excavating and material handling equipment must be shown. They accept statements of performance and reliability only when proved. And well they may, as their past experiences with untried equipment have demonstrated.

Speeder owners are our best sales representatives. They speak with authority, because the machine has demonstrated its worth on their own work. So if you want the facts, look up a Speeder owner, and ask him.

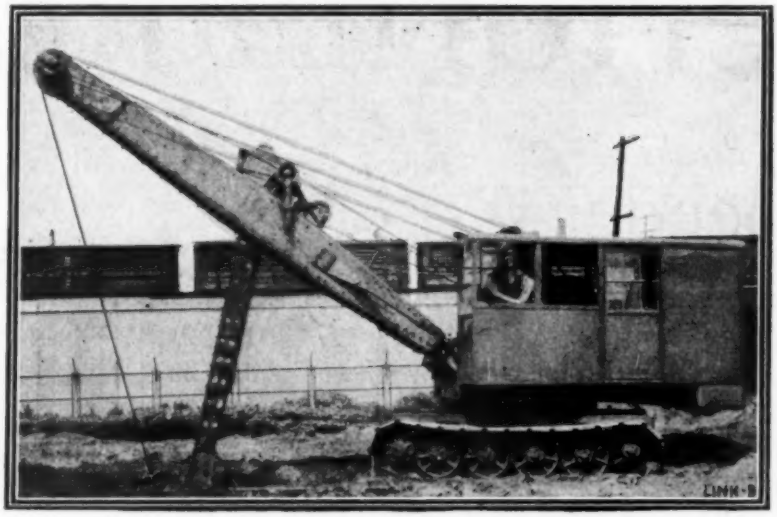
Speeder Machinery Corporation

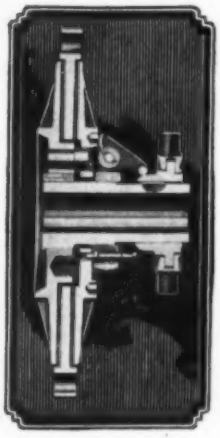
CEDAR RAPIDS, IOWA

(Formerly Fairfield, Iowa)

Write for Bulletin 205

Power Shovels





TWIN DISC CLUTCHES

SERVICE TO USERS

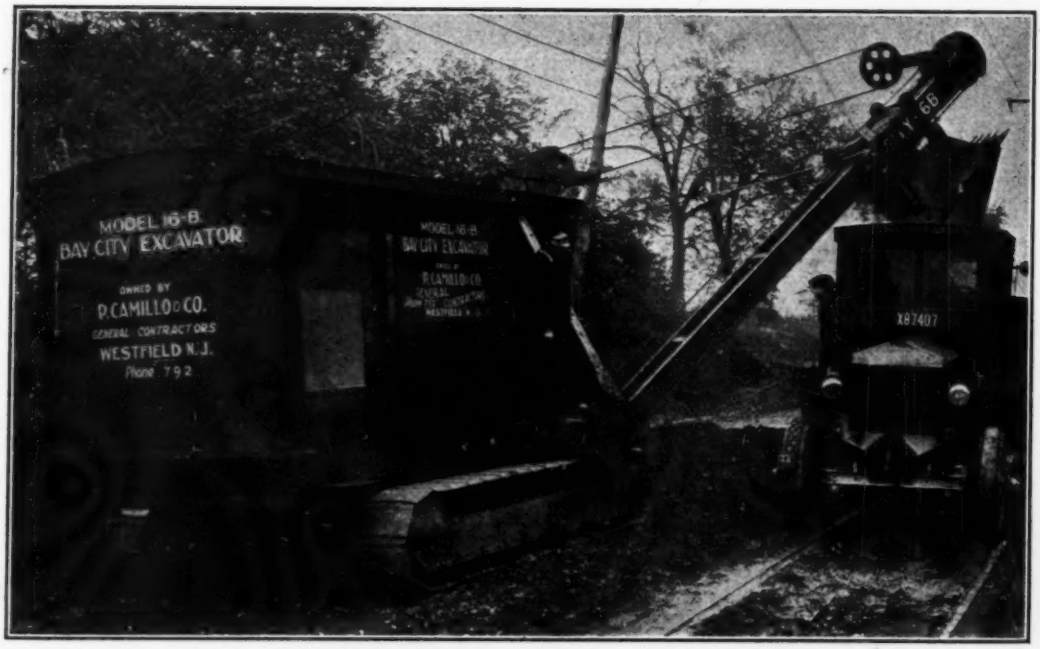
WHENEVER repair parts are needed for Twin Disc clutches on tractors, road machinery, material handling machinery or any others of the numerous machines now equipped with Twin Disc clutches, time may be saved by calling on or writing to the nearest Repair Parts Station.

REPAIR PARTS STATIONS

San Francisco—F. Somers, Peterson Co., 57 California St.
Los Angeles—Coast Machinery Corporation, 406 E. Third St.
Chicago—Motive Parts Co. of America, Inc., 2419 Indiana Ave.
Des Moines—Motive Parts Co. of America, Inc., 1204 W. Grand Ave.
Detroit—Whitney Brothers, 6464 Epworth Blvd.
New York City—R. George & Co., Broome & Wooster Sts.
Raleigh, N. C.—Motor & Equipment Co., 215 E. Davie St.
Cleveland—James R. Howell, 6715 Quimby Ave.
Tulsa, Okla.—Buda Engine Service Co. of Tulsa, Inc.
Tampa, Fla.—Motive Parts Co. of Florida, Inc., 213B Hyde Park Ave.

TWIN DISC CLUTCH COMPANY

RACINE WISCONSIN



Just What You Need For Road Construction

This shows our latest model 16-B Skimmer tearing up the old road between New Brunswick and Boundbrook, N. J., preparatory to resurfacing with concrete. It is owned by P. Camillo & Co., General Contractors, Westfield, N. J.

The moving parts of the crawlers are enclosed on three sides to keep out dirt.

In addition to Skimmer, it will handle Trench Scoop, Dragline or Crane Buckets. The full crawler mounting gives great speed, mobility, traction. Since the cab does not swing, this machine can operate in narrow quarters. All steel construction. Write for details of this great profit-booster.

HAVE YOU SEEN
THE NEW
BAY CITY TRACTOR SHOVEL?

The fastest moving and operating convertible Shovel-Crane.

International-McCormick-Deering Tractor

Look for the 16-B and the Bay City Tractor Shovel at the Road Show

Chicago—January 10-16 Inc.

¾ yd. Buckets
3½ mi. per hr.
5 trips per minute

BAY CITY DREDGE WORKS

New York Office: 302 Broadway **DREDGES POWER SHOVELS CRANES** **BAY CITY, MICH.**

An Insley Excavator, Perfex-cooled in Guatemala, C. A. "This machine has been running day and night shifts with the temperature averaging between one hundred and one hundred and thirty degrees at noon and about seventy-five degrees at night. I have installed four more units." D. Leach, Directing Engineer, Keilhauer & Rodezno, Zacapa, Guatemala, C. A.

We gladly give any information on cooling problems. Our engineering department is ready and willing to serve. Quotations submitted on your plans and specifications, or we draft special designs complete to meet your requirements.

WHEN OVER 100 MAKERS of high-quality machines—names that have stood at the top for years—use Perfex Bronze-Core Radiators for standard cooling equipment, it would indicate some outstanding and worth-while service not to be found elsewhere.

RACINE RADIATOR CO., *Racine, Wis.*

Pacific Coast Representative:
ENGINEERING & SALES CO., 24 California Street
San Francisco, Calif.

LOOK!

You'll find Perfex Bronze-Core radiators on most of the gas-powered machines at the Chicago Road Show. Our exhibit at the next show will be space EB-9, January 10-14, 1927.

PERFEX
THE PERFECT RADIATOR

STEAM — GAS — OR ELECTRIC DRIVE

Plowing and Loading Old Paving Surface

This is hard, shallow digging—a typical Keystone job. There is no other machine for it. Keystone shovels are now being built heavier, stronger, higher powered than ever before; and they are used for heavy excavation in hard materials with ⅝-yard whirlers five tons heavier; but in the shallow cutting field, 6 inches to 6 feet, the Keystone is unique. Here its 14-foot crowd and flat-bottom Skimmer give it twice the efficiency of any other power shovel.

First cost, moving cost, upkeep and depreciation on the Keystone Shovel are low. It can be turned into a Keystone Trenching Machine by adding a Ditcher Bucket and Attachments costing about $325.00; or it can be equipped with a boom extension and ½-yard clamshell for use as a traction crane. It is an interesting story, told at length in a new Catalog which will go at your request.

CAN be fitted also with Ditcher, or Clamshell Bucket for ditching, back filling, cellar-digging, or unloading cars. A general utility traction shovel with all the efficiency of specialized design.

TRADE MARK
KEYSTONE
REGISTERED U. S. PATENT OFFICE

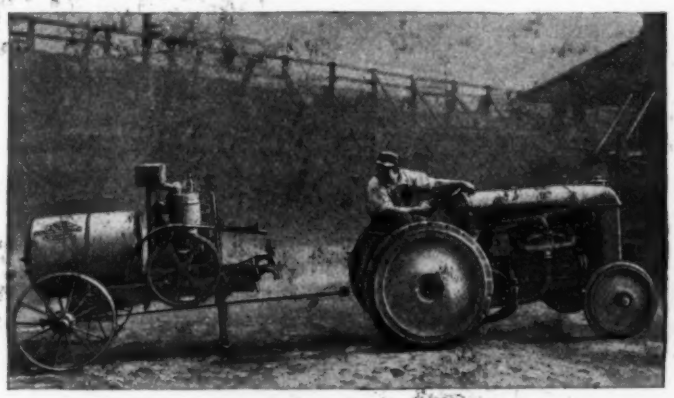
KEYSTONE DRILLER COMPANY — BEAVER FALLS, PENNA.

170 BROADWAY, NEW YORK MONADNOCK BLOCK, CHICAGO JOPLIN, MO.

KEYSTONE SHOVEL

11-D-31

At the Road Show



Chicago Jan. 10, 1927

What high-grade compressor equipment is priced so low as the combination of these standard units?

The combined Curtis Portable Compressor, with Fordson tractor, costs *complete* considerably less than any comparable equipment! The reasons: Both units are completely standardized. Both are manufactured by large, well financed, long established companies. Both are produced in quantity by the most modern cost-saving methods.

If other compressor mountings were equally effective, not being so economically manufactured they would have to cost you more—for no greater value.

The Curtis Portable Compressor, both powered and propelled by Fordson, is likewise the most economical to *operate*; while its extreme *mobility* is a valuable added advantage for which you pay nothing extra.

So fundamental are the advantages of this unit; so radical its cost savings; so versatile its ability to handle various kinds of wo.k; that contractors are finding it the one best compressor unit on which to *standardize*, taking the place of other types.

No matter what kind of work you do requiring compressed air, you should purchase no additional equipment without first thoroughly investigating the low-priced Curtis Portable Compressor.

List Price, Curtis Unit Only (STEEL WHEELS) $900 SUBJECT TO DISCOUNT

MAIL COUPON TODAY

CURTIS Pneumatic Machinery Co.
1935 Kienlen Ave., St. Louis
Branch Office, 515-KHudson Terminal, N. Y.

Gentlemen:
Please send at once full information about the Curtis Portable Compressor, powered and propelled by Fordson tractor. I prefer to deal through [dealer].....

Name.....

Address.....

Write character of work in margin or by letter.

CURTIS COMPRESSOR PORTABLE

Both powered and propelled by Fordson Tractor

CURTIS PNEUMATIC MACHINERY COMPANY, ST. LOUIS, U.S.A.

As Simple as— 2 2/4

THE economy of Butler Bins can be figured in terms of *square yards of pavement*. A contractor had two bins (this is a true story). One of them was a "Butler"—the other was something else. He had to move three miles. He loaded his "Butler," moved it and set it up on the new job in four hours. The other took him three days.

In terms of *road built* his other bin cost him two and a half days or about 5,000 square yards of road.

Butler Bins are sturdy—they stand the gaff. They're built for just the kind of a job you're doing—and they save you money.

BUTLER BIN COMPANY

WAUKESHA-WISCONSIN

Sullivan 220-Foot Compressor Runs Four Heavy Busters

Contractors Mazzola - Marano had a hurry-up concrete busting job in Philadelphia. They put on four of their heavy concrete breakers and ran them 24 hours a day with a Sullivan 220-foot portable compressor.

All four tools smashed away steadily at the street pavement, under 80 pounds pressure. Then came the concrete foundations of the elevated railroad (you know how hard that stuff is). Here the compressor kept three tools going.

"Balanced-V" cylinders, vibrationless operation, and "Wafer" valves helped keep up the pressure. You'll say "the concrete breakers must have been good ones." They were—They were Sullivan "Busters".

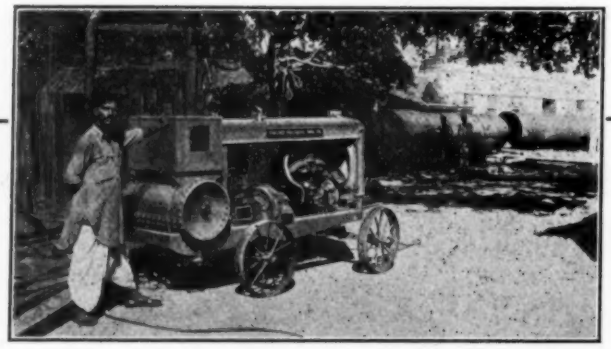
Sullivan Compressors are built in capacities of 110 to 320-cu. ft., driven by Buda gasoline engine or by electric motors; mounted on steel wheels, rubber-tired trailers, skids, or ready for mounting on truck. Sullivan "Busters" are made in light and heavy models. (48 and 75 lbs.)

Write Today For These Catalogues

Portable Compressors	*Bulletin 583-D*
Concrete Breakers	*Bulletin 581-I*

SULLIVAN MACHINERY COMPANY

130 SOUTH MICHIGAN AVENUE **CHICAGO, ILLINOIS, U. S. A.**

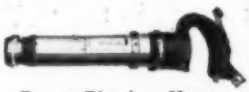


CP Equipment in India

The Chicago Pneumatic Portable Compressor shown above is supplying power for Boyer Riveting and B-K (Boyer-Keller) Chipping Hammers on the 36-mile pipe line from Pulta to Calcutta, India, where typically efficient service is being rendered.

Chicago Pneumatic Portable and Stationary Compressors are supplied in steam, oil, belt and direct motor driven types to meet all compressed air requirements. CP Portable Compressors are mounted on flanged, steel and solid rubber tired wheels, or on skids.

B-K (Boyer-Keller) Chipping Hammers are made in five sizes for all chipping, calking, and beading needs. Great power, minimum vibration, perfect balance and high speed assure the operating efficiency of these tools.



Boyer Riveting Hammers are the standard wherever rivets are driven. Made in types and sizes to meet every riveting need.

Our engineers will be glad to discuss Chicago Pneumatic equipment as applied to your particular needs.

Chicago Pneumatic Tool Company

6 East 44th Street, NEW YORK, N. Y.

*Sales and *Service Branches all over the World*

*Birmingham	*Cleveland	Houston	*New York	*San Francisco	*Berlin	Calcutta	Helsingfors	*London	Moncton	*Paris	*Sao Paulo	Timmins
*Boston	Dallas	Knoxville	*Philadelphia	*Seattle	Bogota	Copenhagen	Honolulu	Madrid	*Montevideo	Ponce	Seoul	Tokyo
Buffalo	Denver	*Los Angeles	*Pittsburgh	*St. Louis	*Bombay	Dairen	*Johannesburg	Manila	*Montreal	Rio de Janeiro	Stockholm	*Toronto
*Chicago	*Detroit	*Minneapolis	Richmond	Tulsa	*Brussels	*Durban	Kobe	*Mexico City	Osaka	*Rotterdam	Sydney	*Vancouver
*Cincinnati	El Paso	*New Orleans	Salt Lake City	Athens	*Buenos Aires	*Havana	Lima	*Milan	Oslo	Santiago	Tampico	*Winnipeg

Canadian Pneumatic Tool Company, Ltd., Montreal, manufacturers of Chicago Pneumatic products in Canada
Consolidated Pneumatic Tool Company, Ltd., London, manufacturers of Chicago Pneumatic products in England

C-236

CHICAGO PNEUMATIC AIR COMPRESSORS • BOYER PNEUMATIC HAMMERS • ROCK AND COAL DRILLS • CONDENSERS
LITTLE GIANT PNEUMATIC AND ELECTRIC TOOLS • GIANT OIL AND GAS ENGINES • VACUUM PUMPS • OIL BURNERS
PAINT SPRAYERS • TOOL BALANCERS — PNEUMATIC HOISTS • SAND BLASTERS

CHICAGO *Depend upon* **PNEUMATIC** *that Name*

CALLS FOR BIDS

OFFICIAL PROPOSALS

COPY for official proposals reaching our 221 E. 20th St. Chicago office on the 7th, 17th, and 27th of the month can usually be printed in the magazine issued 3 days later.

Rate: 50 cents a line an insertion

BIDS FOR OUTFALL SEWER

Notice is hereby given that the City Council of the City of Grand Island, Nebraska, will receive sealed bids for the construction of an Outfall Sewer, according to plans, specifications and estimate of the city engineer. The engineer's estimate of the cost of the construction of so much of the said work as is contemplated contracting for at this time is as follows:

1,700 lin. ft. sewer complete with all M. H., section, etc., @ $22.00 per foot, $37,400.

Engineering, inspection, and publication, @ 5 per cent, $1,870.

Total, $39,270.

Bids will be received upon 90-inch re-inforced concrete pipe, on 90-inch segment blocks and on re-inforced concrete monolithic section as per plans and specifications of the city engineer.

Plans and specifications may be obtained from the office of Kenneth Y. Craig, city engineer of Grand Island, upon the deposit of the sum of $10.00.

Bids will be filed with the undersigned by 8 o'clock P. M., of Wednesday, December 15, 1926, accompanied with 5 per cent of amount of bid in each case.

The City Council reserves the right to reject any and all bids.

By order of the City Council, Grand Island, Nebraska, November 9, 1926.

H. E. CLIFFORD, City Clerk.

TREASURY DEPARTMENT, Office of the Supervising Architect, Washington, D. C., November 19, 1926.—SEALED PROPOSALS will be opened in this office at 3 P. M., December 15, 1926, for the construction, including mechanical equipment and approaches of a two story and basement brick and stone fireproof building for the United States Post Office at Cody, Wyo. Drawings and specifications may be obtained from the custodian of the site at Cody, Wyo., or at this office in the discretion of the Supervising Architect.

JAS. A. WETMORE,
Acting Supervising Architect.

TREASURY DEPARTMENT, Office of Supervising Architect, Washington, D. C., November 19, 1926. SEALED PROPOSALS will be opened in this office at 3 P. M., December 15, 1926, for the construction including mechanical equipment and approaches of a two story and basement brick and stone fireproof building for the United States Postoffice at Buffalo, Wyoming. Drawings and specifications may be obtained from Custodian of the site, Buffalo, Wyoming, or at this office in the discretion of the Supervising Architect.

JAS. A. WETMORE,
Acting Supervising Architect.

U. S. ENGINEER OFFICE, GALVESTON, TEXAS. Sealed proposals will be received here until 12 M., December 20, 1926, and then opened, for jetty repairs, South Jetty, Galveston Harbor, Texas. Further information on application.

Heil Dump Unit Mounted on Two-Way Drive Super-Truck

HEIL BODIES and HOISTS

THE illustrations show Super-truck units mounted with Heil Model 30 steel dump bodies and No. 4-26 HEIL Hoists. American Asphalt Paving Co. specified HEIL for their entire fleet.

You can secure HEIL Bodies and Hoists for every make or model motor truck. They give the much-needed reliability to your dump job which helps you profit on your hauling charges. If you are interested in getting the biggest returns out of your dump truck investment write for the new HEIL Demograph Bulletin No. 160. Send for it Today.

THE HEIL CO.

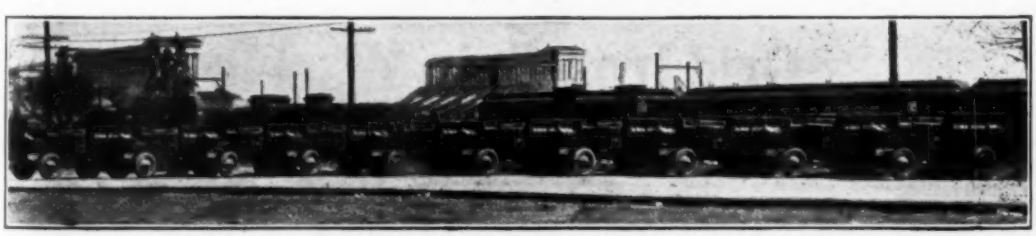
1138-50 Montana Ave. Milwaukee, Wis.

Factory Branches

Chicago Philadelphia Boston New York

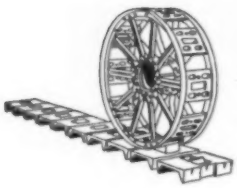
One of our twenty-five distributors is near you.

The HEIL Co. manufactures a complete line of Bodies, Hoists, and Tanks for Motor Trucks.



Ten HEIL Equipped Super-trucks in Service of American Asphalt Paving Co.

Grid-Iron-Grip Wheels are made for Fordson and McCormick-Deering Tractors. Consult your nearest Dealer or Branch for a convincing demonstration of traction efficiency and economy



Loosely-mounted grips (patented) embody the crawler principle in operation. They come down flat, lay a track for the wheel, lift up straight, then clean themselves. Buyer has choice of grip sizes—12", 14", 16" or 18" in width. Quickly attached. All-steel wheel of special design and construction.—Grips are not adapted to standard wheels.

Snow-removal days are here

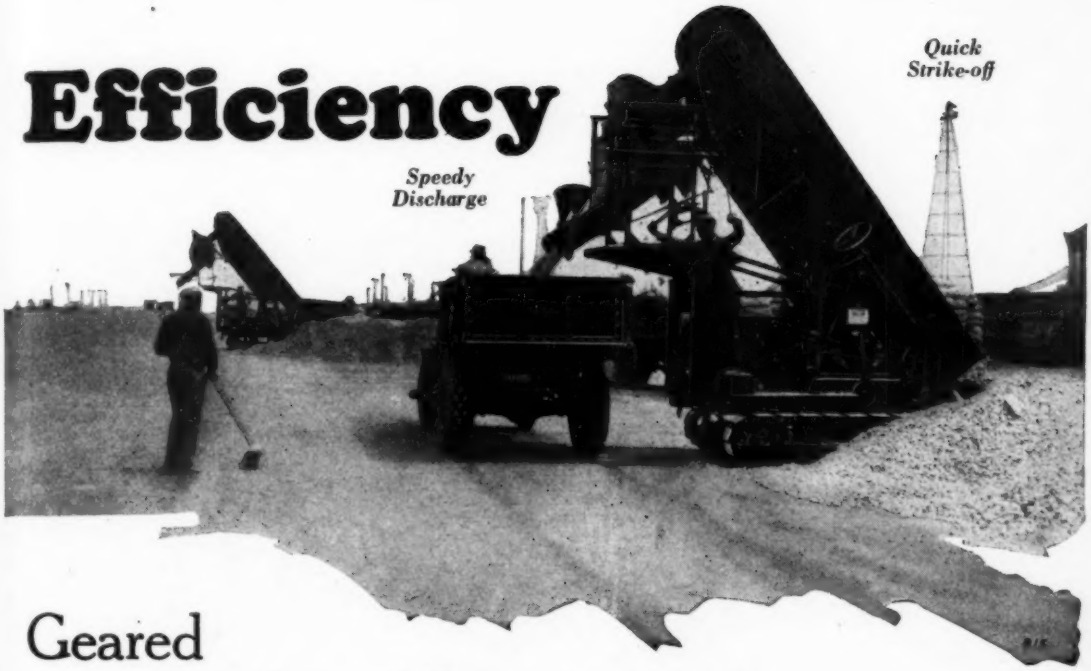
Attach Grid-Iron-Grip Wheels to your Fordsons or McCormick-Deering Tractors and know the true meaning of the word "Performance." Here is the height of traction efficiency, accompanied by economy. Grid-Iron-Grip Wheels embody the crawler principle. Grips lay a track for the wheel. There is no slipping or sliding. Every bit of engine power is delivered into traction. Snow removal can be accomplished in less time because the wheels do not reduce the normal speed of the tractor. Equip your tractor for year 'round usefulness. Write for complete information. The Tractor Grip Wheel Company, 2012 Waterworks Drive, Toledo, Ohio.

Grid-Iron-Grip Wheels
for Tractors

Efficiency

Quick Strike-off

Speedy Discharge



Geared to the Speed Requirements of the 27-E Pavers—

For Stockpile Loading
Light Grading
Excavating Sand
Digging Pit Gravel
Loading Spoil
Grading Alleys
and general utility

Yes, and with a 37 second cycle for the stone loading, strike-off, discharge and reset operation the Haiss Creeper Loader with Precision Measuring Hopper has something over 100% safety factor. Or, to put it another way, if you had trucks enough one Haiss Loader would batch aggregates for two pavers.

The speed in a Haiss Loader comes from the design of all elements for equally high efficiency. And this efficiency is in ease of operation as well as in mechanical excellence. From the positive feeding paddles to the quick-acting hopper discharge the machine moves sand and stone at a rate of some 2 yards a minute.

Ask for your copy of Catalog 523.

Manufacturer of
THE GEORGE
-Truck and- Wagon Loaders
Portable Belt Conveyors

HAISS

143rd St. and Canal Place, New York, N. Y.

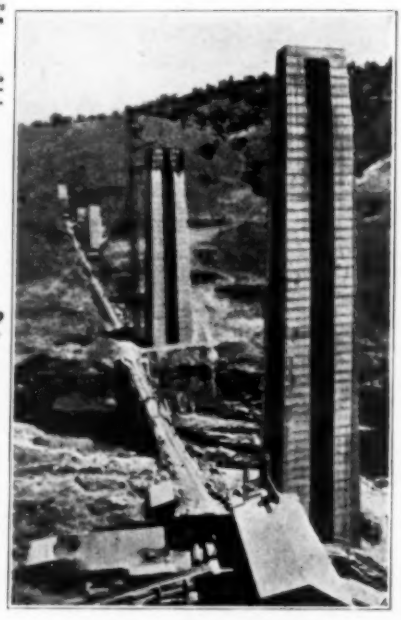
Established 1892
MFG. CO. INC
Clam Shell -- Buckets --
Material Handling Equipment.

Representatives Throughout the World. Millars Timber & Trading Co., London, British Representative.
Cable Address "Coalhoist" New York—"Western Union 5 Letter Edition" Code.

Concrete Bridge Piers, Yosemite Valley Railroad. Bridge will cross reservoir about six miles above Exchequer Dam in Merced River in California. Tallest pier 208 feet high.

* * *

Those in charge of this work: Jerome Newman, Consulting Engineer; Joseph A. Kitts, Concrete Technologist; Lewis H. Tuthill, Testing Engineer.



Quality Concrete *on* Yosemite Valley Railroad

ENGINEERS directing the concrete work for the new Yosemite Valley Railroad bridge piers believe in the practical application of quality design and control to meet job requirements.

After making a careful study of local aggregates, and determining water ratios which would give the required strengths, a system of field experiments was carried on to learn what mixes would give workability with greatest economy.

These experiments were based upon laboratory principles of grading and proportioning the aggregates; but many details of theory were modified in order to meet field conditions as they actually existed on this particular job.

Strength tests, made regularly during the progress of the work, show that specifications are being met fully, and with close uniformity.

For further information about quality control of concrete, write the nearest office listed below. Ask for a copy of "Design and Control of Concrete Mixtures." There is no obligation.

PORTLAND CEMENT ASSOCIATION

A National Organization to Improve and Extend the Uses of Concrete

Atlanta	Denver	Lincoln, Nebr.	Oklahoma City	Salt Lake City
Birmingham	Des Moines	Los Angeles	Parkersburg	San Francisco
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Read what users say—

"I have yet to see a tractor that will outpull the OilPull. It is always ready with plenty of power; handles an 8-foot grader with back-sloper anywhere—with plenty of power to spare."

* *

"OilPull costs less to operate—that is its big advantage on road work."

* *

"There's an awful difference in the fuel cost on my OilPull and other tractors I have used. You're right—OilPull *does* build more miles per gallon."

* *

"I have used the OilPull two solid years on stiff grading work, using a 10-foot grader, and have not had to pay a cent for repairs."

* *

"The OilPull will outlast any other tractor I know of. I have been using a 20-35 OilPull for six years on 76 miles of town roads."

* *

"The service which OilPull has given me, and which I see it giving others, has convinced me that OilPull is the best built tractor on the market. Oil Cooling, Drive-wheel Interlock, Enclosed Gears—are features that appeal to me; but nothing quite comes up to OilPull economy on fuel and upkeep."

* *

"I have used an OilPull for eleven years. Use it now for belt work, but it could be put on the road and do good service any day we need it."

OilPull's most successful year

OilPull closes the most successful year in its history. With the unprecedented increase in the number of OilPulls sold for road building work come frank statements from OilPull users—testimonials that are stronger claims than we have ever made for the OilPull. You have only to read what users say to know the reason for OilPull's sweeping success.

Write to Dept. BF for our special road building catalog.

Advance-Rumely Thresher Co., Inc.
(Incorporated)
Laporte **Indiana**

Light-Weight

15-25 hp.
20-35 hp.

OILPULL

25-45 hp.
30-60 hp.

Road-Building Special

The Advance-Rumley line includes kerosene tractors, steam engines, grain and rice threshers, combine harvesters, husker-shredders, alfalfa and clover hullers, bean hullers, silo fillers, corn shellers, motor trucks and tractor winches.

Serviced through 33 Branches and Warehouses

616

State Road, North of Dyer, Ind.

Lincoln Highway Detour, South of Dyer, Ind.

THE TWO ROADS shown in the above photographs are examples of the results that can be obtained, at very low cost, by the use of Stanolind Cut Back Asphalt for Cold Surface Treatment.

These roads, before treatment, were worn and irregular old asphalt macadam roads. When improvement was started, the road was first prepared by filling in all bad ruts and depressions with a mixture of Stanolind Cut Back Asphalt for Cold Surface Treatment, and well graded stone. This mixture was used cold, and was thoroughly compacted into place.

The Surface Treatment consisted of two applications of Cut Back Asphalt, applied cold, and one application of clean, well graded, washed limestone.

The first application of asphalt was made at the rate of one-tenth gallon per square yard, after the roadway had been cleaned and freed of dust.

The application of stone consists of about twenty pounds per square yard. The stone was dragged until it had developed into a true surface, filling in all exceedingly low areas.

The second application of asphalt was then made at the rate of about fifteen-hundredths of a gallon per square yard.

Heavy traffic was admitted to the road twenty-four hours after the work had been done.

The cost of this kind of treatment is from five to ten cents per square yard, depending on conditions. This figure includes cost of labor, machinery and material.

STANDARD OIL COMPANY

(INDIANA)

General Offices: 910 S. Michigan Avenue CHICAGO, ILLINOIS

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Joliet	South Bend	Mason City	Detroit	WISCONSIN	Minneapolis	St. Louis
Peoria	KANSAS	Sioux City	Grand Rapids	La Crosse		
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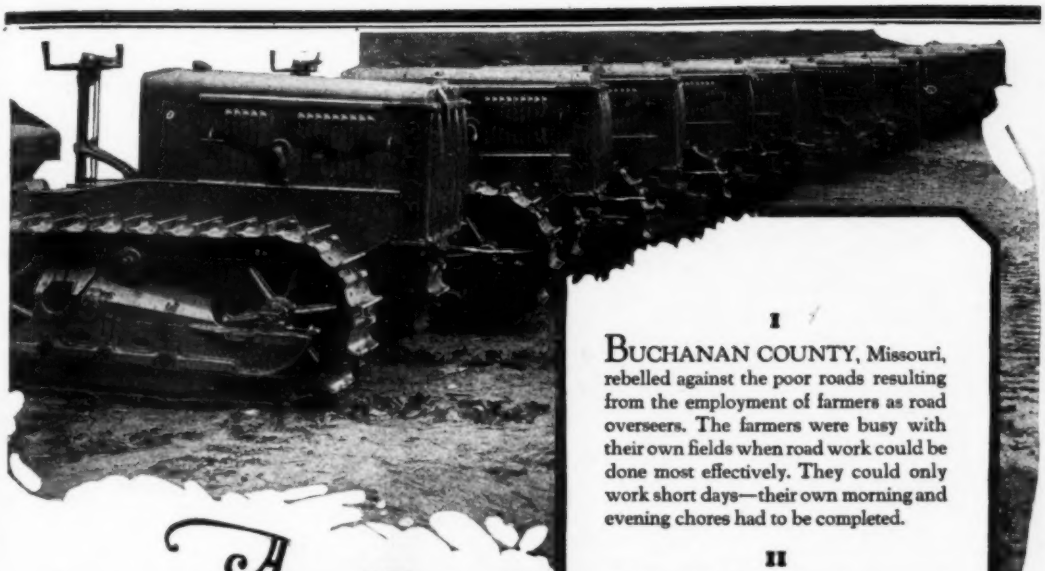

A "Caterpillar" Tractor Scenario Entitled GOOD ROADS—

BETTER
QUICKER
CHEAPER

There is a "Caterpillar" Dealer near you

I

BUCHANAN COUNTY, Missouri, rebelled against the poor roads resulting from the employment of farmers as road overseers. The farmers were busy with their own fields when road work could be done most effectively. They could only work short days—their own morning and evening chores had to be completed.

II

SO they tried out a number of tractors and finally purchased a 2-Ton "Caterpillar".

III

ON the strength of the performance of this tractor, the County then purchased thirteen additional "Caterpillars".

IV

THE forty-one farmer overseers were replaced by fourteen full time patrolmen (each with a tractor) and two road overseers.

V

THE actual recorded saving during the the first quarter of 1926 was $7,945.38—at the rate of $30,000 a year.

VI

AND ROADS WERE BETTER!

"Caterpillar" Tractor Prices

2-TON . $1850
Peoria, Illinois

5-TON . $3250
Peoria, Illinois

THIRTY $3000
Peoria or San Leandro

SIXTY . $5000
Peoria or San Leandro

CATERPILLAR TRACTOR CO.

Executive Offices: San Leandro, California, U. S. A.
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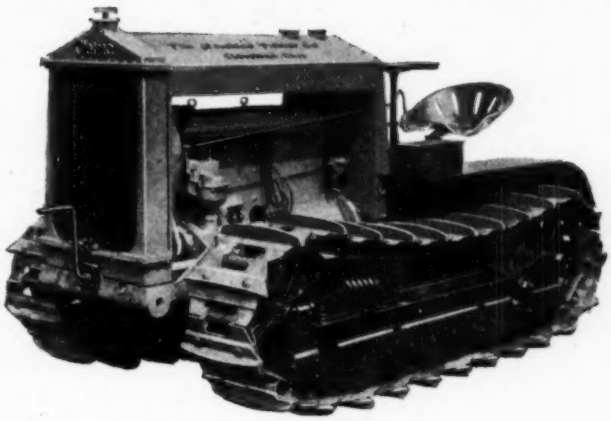
New York Office: 50 Church Street
Successor to
BEST C. L. Best Tractor Co. The Holt Manufacturing Company HOLT

107-1226

CATERPILLAR
REG. U.S. PAT. OFF.

Cletrac
Power and Profit

IN *power, speed* and the application of advanced engineering principles, Cletrac Crawler Tractors are easily the most *profitable* tractor investment.



Nebraska Test Ratings

Official tractor test ratings are available to the public, and wise buyers use them as a guide in making their tractor purchases.

Exclusive Cletrac Features

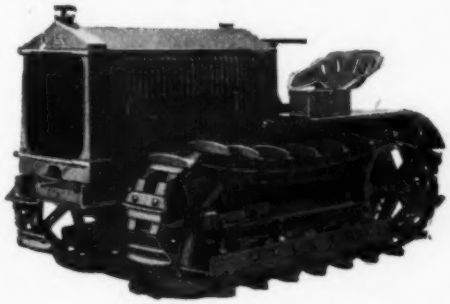
On All Models — Cletrac patented steering arrangement permitting constant power on both tracks when turning. Plain lower track wheel bearings, requiring no adjustment. "Snap" lubrication system; one shot type. *On the Cletrac "30"*—Six cylinder motor. Manganese steel track. Manganese steel drive sprockets.

Nebraska Test Ratings On Cletracs

	At	Cletrac Thirty	Cletrac 2 Ton
Max. Draw Bar Horse Power }	Low	38.58	24.53
Max. Draw Bar Pounds Pull }	Speed	6170	4590
Maximum Belt Horse Power		48.62	30.15
Miles per Hour, High Speed		4.885	4.225

A comparison of these ratings with other tractors of similar rated capacity will be convincing proof of Cletrac's *Power* and *Speed* superiority.

Cletracs Will Be On Exhibit at the Road Show Held in Chicago January 10-14—The CLETRAC Booth is NC-2



Superior Tractor Value

A tractor represents an investment in *Power.* Cletrac power is the most *profitable* Power on the market today figured on a "per mile, per yard or per hour" basis.

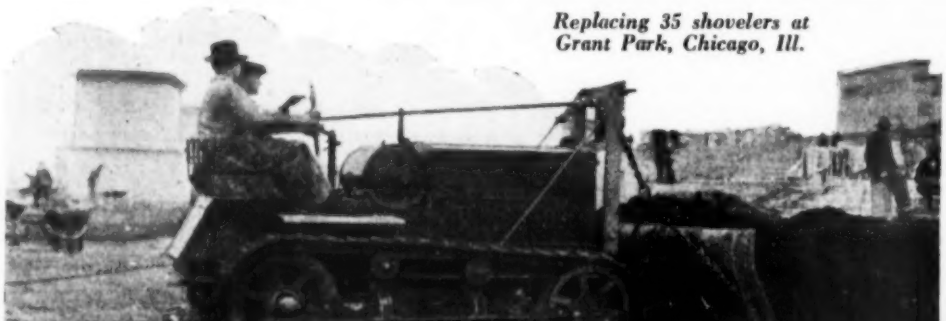
A wire, letter or card will bring a Cletrac representative to you.

The Cleveland Tractor Co., Cleveland, Ohio

SCHRAMM Inc., Manufacturers, West Chester, Pa.

Offices and Representatives in all Principal Cities

SCHRAMM, Inc.



Replacing 35 shovelers at Grant Park, Chicago, Ill.

BATES TRACTORS

3 Sizes
BATES 25
BATES 40
BATES 70

On bull dozing work Bates Tractors lead in the amount of work turned out in a day's time. Only the Bates embodies all three of the elements required for fast bull dozing—long crawlers, fast reverse speed and surplus power.

Write for new catalog.

BATES MANUFACTURING COMPANY

Established 43 years ago.

Joliet, Illinois, U. S. A.

FAST DUMPING
SAFE OPERATING

These are the two outstanding features you seek in all Dump Bodies. But when you can, in addition, secure a non-racking, long lived body, as in the case of the Ditwiler

Ditwiler *Saftee* DUMP BODY HAND HOIST OR GRAVITY OPERATED

then you change an expense to an investment. You can speed up your deliveries and greatly increase the volume of work done.

The unique worm and gear construction of the underbody hand hoist insures easy operation and above all safe operation—like an irreversible steering gear. No back action is possible.

But we can't begin to tell you all—write us for the details. They will interest anyone seeking economy, and are made for most all 2 ton and lighter trucks.

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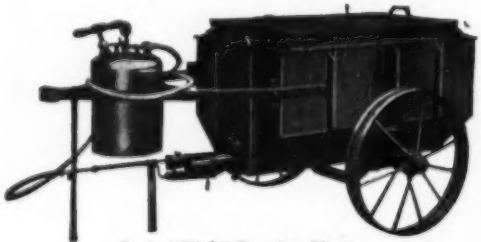
Meet Present Day Methods of Construction



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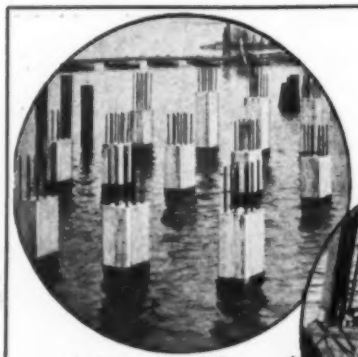
In Connery Tar and Asphalt Heaters contractors will find the very highest development of superior workmanship and design. Kettles are made in twenty styles and sizes, in capacities of 10 to 1000 gallons.

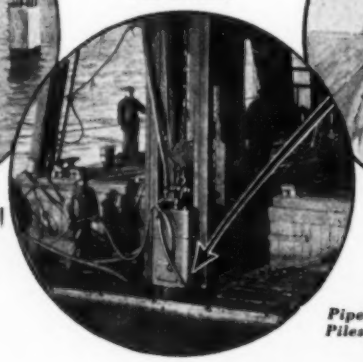
Send for our little "Blue Book" illustrating our many specials in Tar and Asphalt Heaters, Sand and Gravel Dryers, Oil Burning Heaters, Oil Burners, Pouring Pots, etc.

CONNERY & COMPANY, Inc.

3996 N. Second St. **PHILADELPHIA, PA.**

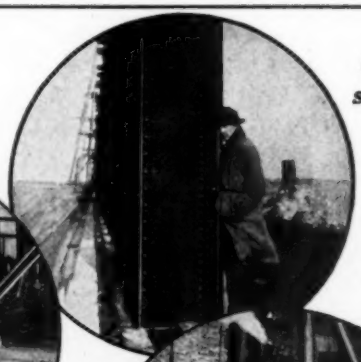


Concrete Monoliths



Submarine Pile Driving

Pipe Piles



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All Kinds

All kinds of modern pile driving, from the heaviest to the lightest, are illustrated in our Bulletin 35. If you have no objection to making more money on pile driving, send for this book and keep it handy. McKiernan-Terry Drill Company, 18 Park Row, New York.

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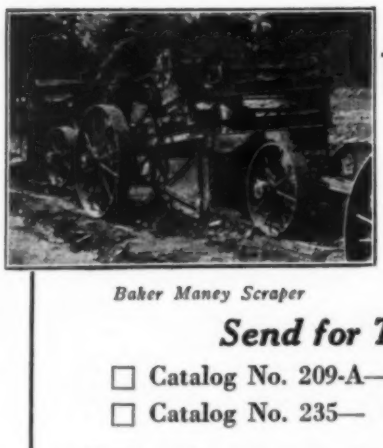

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SNOW PLOWS

Send for These Attractive Catalogs

☐ **Catalog No. 209-A**— Baker Maney Self-Loading Scrapers, Model D—1¼ yard and Model H—¾ yard for tractor use.

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Check catalog you want, sign and mail this advertisement to address below.

Name.....

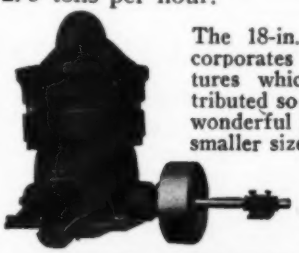
Address.....

THE BAKER MANUFACTURING CO.

506 Stanford Ave., Springfield, Ill.

The New 18-Inch Superior McCully Fine Reduction Gyratory Crusher

The latest development in the Superior McCully Fine Reduction line, furnished to a large Cement Company—having two feed openings, each 18 in. by 68 in.—capable of taking the product from the largest size primary crushers—capacity with minimum discharge opening of 2½ in.—225 to 275 tons per hour.



The 18-in. Crusher incorporates all the features which have contributed so largely to the wonderful success of the smaller sizes of this type.

ALLIS-CHALMERS
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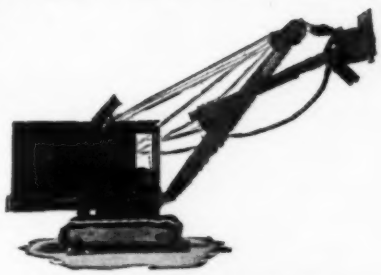
OSGOOD



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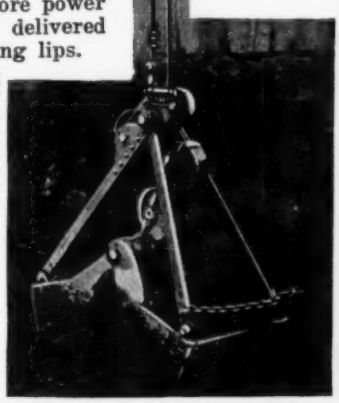
More Power at the cutting lips

The WILLIAMS Bucket's perfectly straight leads of closing cable cut down friction at the sheaves—more power is actually delivered at the cutting lips.

And the Williams is dependable. *All parts guaranteed against breakage, as long as the bucket is used on the classes of work for which we recommend it.*



Write and tell us the kinds of work you have to do, and we'll send detion of the WILLIAMS Bucket for it.

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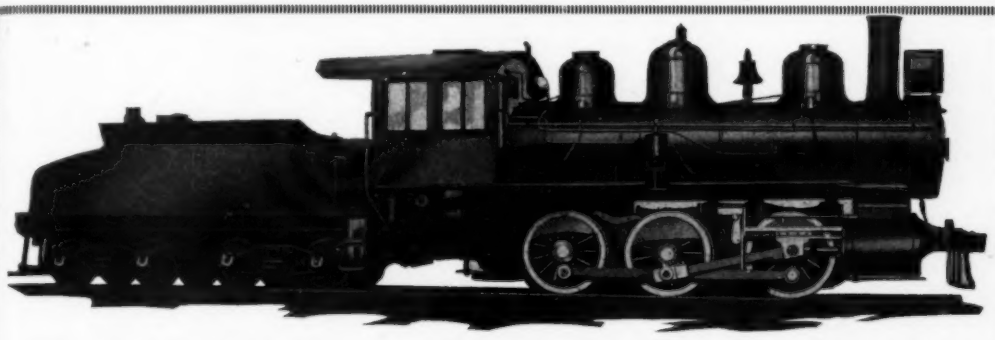

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Est. 1889
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540 Car Spreaders
545 Cars, Concrete
550 Cars, Dump
555 Cars, Industrial
560 Cars, Industrial V Dump
565 Cars, Motor, Railway
570 Cars, Quarry
575 Cars, Side Dump
580 Car Trucks, Roadbuilders'
585 Carts, Concrete
590 Carts, Dump
600 Castings, Iron & Steel
605 Castings, Municipal
610 Catch Basin Covers
630 Cemesit
635 Cement, Acid Proof
640 Cement, Asbestos
645 Cement, Asphalt
650 Cement, Insulation
655 Cement Bag Cleaners & Bakers
660 Cement Colors
670 Cement Guns
675 Cement Hardener
680 Cement, Quicksetting
690 Chain, Steel
695 Chairs, Concrete Supporting
700 Chanellers, Rock
740 Chutes & Elevators, Concrete
745 Chutes & Elevators, Gravel
750 Clamps, Wire Rope
755 Climbers, Track
760 Clips, Track
765 Clips, Wire Rope
770 Clutches
775 Clutches, Magnetic
790 Coaling Stations
795 Coal Storage & Reclaiming Systems
820 Compressors, Air
825 Compressors, Air Portable
830 Concrete Admixture for Workability
835 Concrete Chutes & Hoppers
840 Concrete Curing
845 Concrete Hardener
850 Concrete Highway Reinforcement
855 Concrete Mixers & Placers, Pneumatic
860 Concrete Placing Plants
865 Concrete Reinforcement
870 Condensers, Air
875 Condensers, Steam
890 Contractors, Diamond Drill
905 Conveyors, Belt
910 Conveyors, Bucket
915 Conveyors, Chain
920 Conveyors, Portable Belt
925 Cooling Systems, Gas Engine
945 Covers, Manhole
955 Cranes, Clamshell
1000 Cranes, Crawling Tractor
1005 Cranes, Locomotive
1010 Cranes, Motor Truck
1015 Cranes, Road
1020 Cranes, Traveling
1025 Crawler Attachments
1030 Cribbing
1035 Crimpers, Cap
1040 Crusher Parts
1045 Crushers & Pulverizers
1050 Crushers, Gyratory
1055 Crushers, Portable
1060 Crushers, Portable, with Elevators & Screens
1065 Crushers, Rock
1070 Crushers, Rock, Hammer
1075 Crushers, Rock, Jaw
1080 Crushers, Stationary
1085 Crushing and Screening Plants
1090 Culvert Stock, Copper Alloy
1095 Culverts
1105 Curb, Concrete, Steel Bound
1110 Curbs and Gutters
1112 Curb Guards, Steel
1118 Cutters, Asphalt
1120 Cypress
1130 Derrick Swingers
1135 Derricks & Derrick Fittings
1140 Detonators, Electric
1145 Diggers, Clay
1150 Diggers, Post Hole
1155 Dippers
1160 Dippers, Steam Shovel
1165 Distributors, Calcium Chloride
1170 Distributors, Oil, Tar & Asphalt
1175 Ditchers
1180 Ditchers, Railway
1185 Ditching Machines, Traction
1190 Diving Apparatus
1205 Drafting Machines
1210 Drags, Road
1225 Drawing Materials
1230 Drawing Tables
1235 Dredges, Dipper
1240 Dredges, Suction
1245 Drill Column & Mountings
1255 Drills, Air
1260 Drills, Air Hammer
1265 Drills, Blasthole
1270 Drills, Concrete
1275 Drills, Core
1280 Drills, Earth
1290 Drills, Posthole
1295 Drills, Prospecting (Core)
1300 Drills, Railway Track
1305 Drills, Rock, Pneumatic
1315 Drill Sharpening Machines
1320 Drill Steel Furnaces
1325 Drill Steel, Rock
1330 Dryers, Air
1335 Dryers, Sand and Gravel
1340 Dust Control
1345 Dynamite
1357 Electrical Equipment
1360 Elevators & Conveyors
1365 Elevators, Bucket
1370 Elevators, Gravel
1380 Engineering Instruments
1385 Engineers, Inspecting
1390 Engineers, Testing
1395 Engines, Diesel
1400 Engines, Diesel & Fuel Oil
1410 Engines, Derrick Swinging
1415 Engines, Gasoline
1420 Engines, Hoisting
1425 Engines, Kerosene
1435 Engines, Oil
1445 Engines, Steam, Portable
1450 Engines, Traction, Kerosene
1455 Engines, Traction, Steam
1460 Excavators, Bucket
1465 Excavators, Cableway
1470 Excavators, Crane
1472 Excavators, Ditch & Trench
1480 Excavators, Dragline
1485 Excavators, Dragline, Cableway
1490 Excavators, Sewer & Trench
1495 Excavators, Tower
1505 Explosives
1510 Fabric, Steel, Concrete Reinforcing
1515 Feeders, Reciprocating & Apron
1525 Fence
1530 Fence, Highway
1535 Fillers, Asphalt
1540 Fillers, Bituminous
1560 Finishing Machines, Concrete Road
1605 Flare Lights
1655 Flushers, Street
1660 Forges, Oil & Coke, Drill Steel
1670 Fordson Attachments
1675 Form Clamps & Ties
1680 Formgraders
1690 Forms, Culvert
1695 Forms, Curb & Gutter
1705 Forms, Road
1715 Forms, Sidewalk
1720 Foundations
1725 Foundry Products, Miscellaneous
1735 Frogs, Switches & Crossings
1750 Furnaces, Oil, Drill Steel
1760 Fuse, Detonating
1765 Fuse, Safety
1770 Galvanometers, Blasting
1790 Gates, Bin and Hopper
1800 Gates, Fence
1820 Gear Reduction Units
1825 Gears
1830 Gelatin, Blasting
1835 Generating Sets, Diesel Engine
1840 Generators
1855 Grader Blades
1860 Graders, Elevating
1865 Graders, Patrol, Motor
1870 Graders, Road
1875 Graders, Road, Power
1880 Granite
1885 Grapples, Stone
1890 Gravel Equipment
1905 Grizzlies, Rotary & Stationary
1910 Guard, Highway
1945 Hammers, Piledriver
1950 Hammers, Pneumatic
1955 Hammers, Riveting
1960 Handles, Shovel
1975 Headwalls
1980 Heaters & Dryers, Sand & Gravel
1985 Heaters, Asphalt, Pitch & Tar
1990 Heaters and Patchers, Asphalt Surface
1995 Heaters, Asphalt Tool
2005 Heaters, Car
2010 Heaters, Concrete
2015 Heaters, Kettle
2020 Heaters, Water
2027 Highway Lighting
2030 Highway Signs
2035 Hoes, Trench
2040 Hoes, Patching, Asphalt
2045 Hoisting & Conveying Appliances
2050 Hoists, Air Motor
2055 Hoists, Cableway
2060 Hoists, Contractors'
2065 Hoists, Dragline Scraper
2070 Hoists, Geared
2075 Hoists, Hand
2080 Hoists, Motor Truck
2085 Hoists, Motor Truck, Hydraulic
2090 Hoists, Quarry
2095 Hoists, Scraper Bucket
2100 Hoists, Scraper Loader
2105 Hoists, Screw Chain
2115 Hoppers, Aggregate Measuring
2167 Hose, Tar, Asphalt, Etc.
2195 Hydraulic Mining Nozzles
2210 Inlets, Curb
2220 Inspections & Tests
2225 Instruments & Supplies, Drawing
2230 Instruments, Surveyors'
2240 Insurance and Surety Bonds
2245 Inundators
2250 Irons, Branding
2260 Jacks, Lifting
2270 Joints, Epansion Paving
2280 Kettles, Asphalt
2285 Kettles for Heating Asphalt & Tar
2290 Kettles, Mastic
2295 Kettles, Pouring
2300 Kettles, Roofing
2305 Laboratories, Testing
2330 Lettering Guides
2335 Lights, Contractors'
2345 Lighting Plants, Contractors'
2350 Lighting Standards, Concrete
2270 Joints, Expansion
2375 Loaders, Bucket
2380 Loaders, Car and Wagon
2390 Loaders, Gravel & Sand
2395 Loaders, Portable
2400 Loaders, Snow
2405 Loaders, Truck
2415 Locomotives, Contractors'
2420 Locomotives, Electric
2425 Locomotives, Fuel Oil & Kerosene
2430 Locomotives, Gasoline
2435 Locomotives, Industrial
2440 Locomotives, Steam
2445 Locomotives, Storage Battery
2450 Locomotives, Trolley
2455 Log Loaders
2460 Logging Machinery
2470 Lumber, Creosoted
2485 Magazines, Portable Powder
2490 Magnetos
2500 Maintainers, Road
2505 Manganese Steel Parts
2510 Manhole Covers
2515 Manifolds, Rock Drill
2540 Mesh, Reinforcing Concrete
2590 Mixers, Concrete
2595 Mixers, Concrete Paving
2600 Mixers, Grout
2605 Mixers, Hot
2615 Mixers, Pneumatic
2620 Motors, Air
2630 Motors, Electric
2635 Motors, Gasoline
2640 Motor Truck Accessories
2645 Mountings, Truck, Rubber Tired
2650 Movers, Car
2655 Oilers, Road
2660 Oilers, Road, Pressure
2665 Oilers, Rock Drill
2680 Oils, Road
2710 Paint, Traffic
2715 Painting, Compressed Air Equipment
2720 Paint Sprayers
2755 Parts, Road Machinery
2760 Parts, Shovel
2765 Parts, Trench Machine

Have You Catalogs on These Things?

The useful information and the suggestive hints in catalogs are far greater than is generally appreciated. Send us a signed post card writing thereon the key number opposite the class of product you are interested in, and mail to Engineering and Contracting Publishing Co., 221 East 20th Street, Chicago, Illinois. We will then ask the manufacturers to send their catalogs. R&S GC

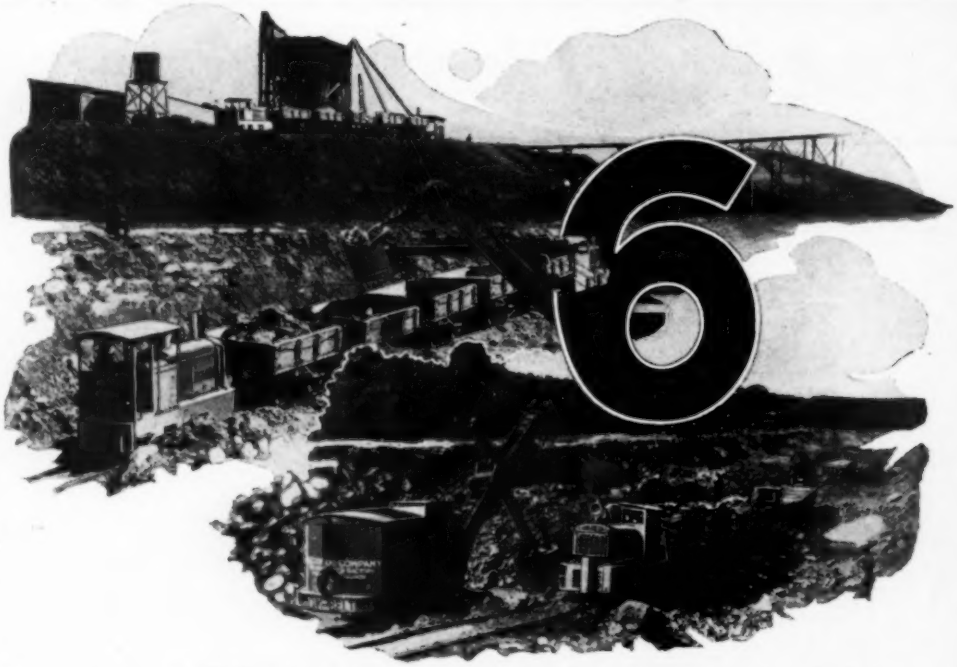
2770 Patch, Cold, Bituminous
2775 Patchers, Asphalt Surface
2780 Pavements Bituminous
2785 Pavers
2790 Paving Blocks
2795 Paving Gauges
2800 Paving, Concrete
2805 Paving Guards
2810 Paving Process, Special
2815 Pens, Lettering
2820 Picks & Shovels
2825 Piledrivers
2830 Pile Hammers, Steam
2835 Piles, Creosoted
2840 Piles, Screw
2845 Piling, Concrete
2850 Piling, Sheet Steel
2855 Piling, Wood
2880 Pipe, Culvert
2885 Pipe, Drain
2890 Pipe, Dredge & Pontoon
3060 Planers, Road
3065 Planers, Subgrade
3115 Plows, Grading
3120 Plows, Road
3125 Plows, Rooter
3130 Plows, Snow
3135 Plows, Spreader
3140 Plows, Unloading
3155 Poles
3160 Post and Pole Machinery
3165 Post Molds and Machines
3170 Posts, Fence
3175 Posts, Mile and Whistle
3190 Pouring Gates
3195 Powder, Blasting
3200 Powder, Railroad
3210 Power Units, Gasoline
3215 Power Units, Take-Off
3225 Pulling Machines
3230 Pulleys, Clutch
3275 Pumps, Asphalt
3280 Pumps, Ballast
3295 Pumps, Centrifugal
3300 Pumps, Contractors'
3315 Pumps, Drainage
3320 Pumps, Dredging & Sand
3335 Pumps, Force
3340 Pumps, Gasoline & Oil
3345 Pumps, Hand
3360 Pumps, Piston
3365 Pumps, Plunger
3370 Pumps, Quarry
3380 Pumps, Roadbuilders'
3400 Pumps, Sump
3405 Pumps, Trench, Portable
3410 Pumps, Triplex
3430 Pumps, Wrecking
3440 Radiators, Engine and Motors, Gasoline
3450 Rail and Rail Joints, Fastening & Specialties
3460 Rails
3465 Rails, Road Form
3470 Railway Equipment, Industrial
3475 Railways, Industrial & Portable
3480 Rakes, Asphalt
3485 Rammers, Pneumatic
3500 Receivers, Air
3515 Reinforcement, Wire Mesh
3525 Retreaders, Asphalt Paving
3530 Rheostats, Blasting
3545 Road Forms, Steel Rail
3550 Road Machinery Parts
3555 Road Oilers
3560 Rock Drill Accessories
3565 Rockers, Bridge
3580 Rollers, Road
3585 Rollers, Road, Gasoline
3590 Rollers, Road, Horse Drawn
3595 Rollers, Road, Steam
3600 Rollers, Road Tandem
3605 Rollers, Road, Tandem, Steam
3610 Rolls, Recrushing
3630 Rooters
3635 Rope, Manila
3640 Rope, Wire
3645 Rope, Wire, Lubricants
3650 Rope, Wire, Fittings
3655 Rules, Calipers, Tapes, Etc.
3660 Sack Balers
3665 Sack Cleaning Machines
3670 Salamanders
3675 Sand and Gravel Handling Machinery
3680 Sand and Gravel Plants
3695 Saw Rigs
3700 Saws, Rail
3705 Scales, Motor Truck
3710 Scarifier Teeth
3715 Scarifiers
3720 Scarifiers, Grader
3725 Scarifiers, Road
3730 Scoops & Spades
3735 Scrapers, Drag
3740 Scrapers, Drag, Power
3745 Scrapers, Fordson Power
3750 Scrapers, Fresno
3755 Scrapers, Four Wheel, Self Loading
3760 Scrapers, Mormon
3765 Scrapers, Slip
3770 Scrapers, Tractor
3775 Scrapers, Wheeled
3780 Screening Plants, Sand and Gravel
3785 Screen, Gravel Washing
3795 Screens, Revolving
3800 Screens, Sand and Gravel
3810 Screens, Stone
3860 Shanking Machines, Drill Steel
3865 Sharpeners, Rock Drill, Steel
3880 Sheaves
3910 Shovel (Power) Parts
3915 Shoveling Machines
3920 Shovels, Asphalt
3925 Shovels, Electric
3930 Shovels, Electric Crawler
3935 Shovels, Fordson
3940 Shovels, Gasoline
3945 Shovels, Gasoline, Crawler
3950 Shovels, Hand, Contractors'
3955 Shovels, Revolving
3960 Shovels, Steam
3965 Shovels, Steam, Crawler
3975 Sidewalk Lights
3985 Sign Posts
3990 Signs, Highway
3995 Signs, Street
4005 Skips, Cableway
4030 Smoothers, Asphalt
4035 Snow Removal Machinery
4050 Spacers, Bridge, Highway
4055 Spacers, Culvert, Concrete
4060 Spaders, Clay
4065 Spacers, Slab, Concrete
4070 Spikes, Railroad
4075 Spreaders, Sand
4080 Spreaders, Stone & Gravel
4085 Sprinklers, Road and Street
4090 Sprockets, Chain, Sheaves
4095 Squeegees
4100 Squibs, Electric
4105 Stakes
4160 Stoneboats
4165 Stone Skips
4175 Street Lights
4180 Strip, Road
4185 Strips, Pins and Accessories for Concrete Road Reinforcement
4190 Stump Pullers
4195 Subgrading Machines
4200 Surety Bonds
4205 Surfacers, Road
4210 Surveying Instruments
4215 Sweepers, Street
4220 Switches, Portable
4225 Tablets, Bronze
4230 Tables, Transfer
4235 Tampers, Asphalt
4240 Tampers, Backfill
4245 Tampers, Power
4270 Tanks, Sand Settling
4275 Tanks, Sprinkling
4285 Tapes, Metallic
4300 Tar, Road
4305 Tar and Pitch, Paving
4310 Teeth, Dipper and Bucket
4315 Templets, Subgrade
4320 Templets, Strike-Off
4325 Templets, Wood, Paving Gauge
4330 Tents, Awnings and Tarpaulins
4335 Testing Machines, Cement
4340 Testing Machines, Cement & Road Materials
4345 Tests, Road Material
4346 Thawing Outfits, Concrete
4348 Tie Tampers, Pneumatic
4350 Ties, Steel
4375 Tool Boxes
4380 Tools, Asphalt Paving
4395 Tools, Hand, Blacksmith
4405 Tools, Mechanics'
4415 Tools, Pneumatic
4420 Torches, Gasoline
4425 Torches, Kerosene
4430 Torches, Thawing, Oil and Kerosene
4435 Track, Industrial and Portable
4440 Trackpull
4445 Tracks, Rail
4450 Traction, Crawling Type
4455 Tractor Crawlers
4460 Tractors
4465 Tractors, Caterpillar
4470 Tractors, Crawler Traction
4480 Tractors, Road
4485 Tractors, Road, Gasoline
4490 Tractors, Truck
4495 Tractors, Wheel
4500 Traffic Signals
4505 Traffic Treads
4510 Trailers
4515 Trailers, Drop Frame
4520 Trailers for Heavy Equipment
4525 Trailers, Logging and Pole
4530 Trailers, Motor Truck
4535 Trailers, Roadbuilders'
4540 Tramways
4545 Transits and Levels
4565 Truck Cranes
4570 Truck Dumps
4573 Truckmixers
4575 Trucks, Dump
4580 Trucks, Machinery
4585 Trucks, Motor
4590 Trucks, Motor, Special Roadbuilders'
4595 Trucks, Portable Machinery
4600 Trucks, Road, Batch Box
4625 Turnouts
4630 Turntables, Industrial Railway
4635 Turntables, Motor Truck
4640 Unloaders, Ballast
4645 Unloaders, Car and Wagon
4650 Unloaders, Coal, Stone
4655 Unloaders, Conveyor
4660 Unloading Plants
4665 Used Equipment
4745 Wagons, Asphalt
4750 Wagons, Dump
4755 Wagons, Dump, Horse Drawn
4760 Wagons, Sprinkling
4765 Wagons, Stone Spreader
4785 Washing Plants, Sand and Gravel
4800 Water Jets
4820 Waterproofing Oil, Asphalt
4855 Weed Killer
4900 Wheelbarrows, Coal
4905 Wheelbarrows, Concrete and Mortar
4910 Wheelbarrows, Contractors'
4915 Wheelbarrows, Steel Tray
4920 Wheelbarrows, Stone
4925 Wheels, Metal
4930 Wheels, Rubber Tired
4935 Winches
4940 Winches, Motor Truck
4960 Wire and Cable
4970 Wire, Leading and Connecting
4975 Wire Rope
4980 Wire, Steel
4995 Wrenches and Ratchets

AFTER examining our Advertising and Clearing House pages, if you can't find the equipment you are seeking, write us regarding your wants and we will gladly direct you to the concerns that can supply you.

Classified Products

Index to Advertisers

***Products are described in Road and Street Catalog.**



It's 6 "Whitcombs" This Time

At Starved Rock on the dam project six 12-ton Whitcomb locomotives are being used for hauling material to the dump. Four and five loaded cars are hauled over an 8 per cent grade from the excavation to the disposal pile, which is on a 35-foot higher level.

Again "Whitcombs" are proving their superiority—day in and day out they are keeping several shovels busy—their more horse power per ton of weight (10 to 16 horse power per ton) is necessary where faster operation is essential.

Put a "Whitcomb" on your work—watch how it speeds up operations—note that operators prefer "Whitcombs" because of their smooth operation—easier spotting of cars—faster starting and stopping—and comfortable cabs.

Faster operation means more profits—only "Whitcombs" can guarantee it. May we help you to select the proper size locomotive for your work?

GEO. D. WHITCOMB COMPANY
ROCHELLE, ILLINOIS
Offices in principal cities

GASOLINE – STORAGE BATTERY – ELECTRIC

WHITCOMB
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